COMPARISON OF PROCEDURES FOR TESTING THE HYPOTHESIS OF A DIFFERENCE BETWEEN r 1 AND r 2 USING INDEPENDENT AND DEPENDENT SAMPLES

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Introduction

Completion of correlation studies may require that the researcher test for significant differences between two independent correlations and/or between two dependent correlations. Solutions to the former problem may be found in many basic statistics books (Tate, 1965; McCall, 1970; Dayton, 1971; Minium, 1978). Procedures to test for a significant difference between dependent correlations have also been reported (Glass and Stanley, 1970; Hinkle, Wiersma and Jurs, 1979). Minium (1978) reported that there was no entirely satisfactory test of the difference between correlations from dependent samples, but it is not known whether he was familiar with the procedure presented by Hinkle, Wiersma and Jurs in 1979.

Method for Study One

Newman[1] suggested that differences between correlations from both dependent and independent universes could be tested for significance using multiple linear regression (MLR). This application of the use of MLR had not been previously demonstrated. While testing for a difference between r_s of independent universes appeared to be relatively uncomplicated using MLR, such was not the case when the test was applied to data from dependent universes. In the latter case repeated measurers were made, hence it was necessary to include Person Vectors in the statistical models developed. Peddhazur, 1977 reported a procedure for inclusion of Person Vectors in MLR models, but no analogue procedure was given when the dependent variable was dichotomous. This paper presents such an analogue procedure and demonstrates its appropriateness.

Results of using the procedure reported by Minium, 1978 to test for a significant difference between r_1 and r_2 using independent samples and the procedures reported by Glass and Stanley, 1970, and by Hinkle, Wiersma and Jurs, 1979 for testing the difference between r_1 and r_2 using dependent samples were compared to results using the general MLR approach suggested below. Study of the outcome for the independent sample case was based upon a Monte Carlo approach in which 100 pairs of samples of 30 subjects each were taken from the Coleman Data Bank. The criterion vari-

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[1] Newman made the suggestion in planning the present paper.

able was sex (Y) and the predictor variables were GPA (X_1) and reading achievement (X_2). In the dependent case the same variables were used, but the subjects in sample 1 were the same subjects as those in sample 2. Using a Monte Carlo procedure, 100 samples of 60 subjects each were created from the Coleman Data Bank. When these subjects were considered to be in sample 1, a correlation (r_1) was calculated between GPA and sex. When the same subjects were in sample 2 a correlation (r_2) was calculated between reading achievement and sex.

<u>Comparison of Minium's Suggestion (z test) to MLR for Testing $H_0: r_1 - r_2 = 0$, $H_A: r_1 - r_2 \neq 0$, $\alpha = .05$ for Independent Sample Data.</u>

Using a Monte Carlo procedure 100 pairs of independent samples were drawn. Correlations (r_1 and r_2) were run between sex (Y) and GPA (X_1) and sex (Y) and reading achievement (X_2). To determine if there was a significant difference between r_1 and r_2 using the z test the following formula was applied:

Formula One:

$$z = \frac{z_{r_1} - z_{r_2}}{\sqrt{\frac{1}{n_1 - 3} + \frac{1}{n_2 - 3}}}$$

Fisher's z equivalents were used rather than r values because the sampling distribution of the r values is likely to be skewed. Values of z obtained for the 100 pairs of samples are reported in Table 1. Inspection of the z scores indicates that only two reached a magnitude greater than 1.96. Twice the null hypothesis was rejected with alpha set at the .05 level.

To determine if there was a significant difference between r_1 and r_2 with the same data using MLR, variables X_1, X_2 and Y were transformed into standard scores to obtain common units of measurement. Using the following regression models, the hypothesis $H_o: a_1 = a_2$ (where a_1 and a_2 are partial regression weights) was tested.

Full Model 1 VS Restricted Model 2

$$z_y = a_1 z_{x1} + a_2 z_{x2} + E_1 \quad \text{VS} \quad z_y = a_2 z_{x3} + E_2$$

(In standard score form z_{y1} represents sex, z_{x1} represents GPA, z_{x2} represents reading achievement and z_{x3} represents the predictor score regardless of whether the person came from sample 1 (s_1) or sample 2 (s_2); $z_{x3} = z_{x1} + z_{x2}$; a_3 represents the common slope for a_1 and a_2.)

Full Model 1

Model 1 $z_y = a_1 z_{x1} + a_2 z_{x2} + E_1$

	z_{y1_1}	z_{x1_1}	0	-
	z_{y1_2}	z_{x1_2}	0	-
s_1	.	.	.	.
	.	.	.	.
	$z_{y1_{30}}$	$z_{x2_{30}}$	0	-
	z_{y1_1}	0	z_{x2_1}	-
	z_{y1_2}	0	z_{x2_2}	-
s_2	.	.	.	.
	.	.	.	.
	$z_{y1_{30}}$	0	$z_{x2_{30}}$	-

Restricted Model 2

Restriction: $a_1 = a_2$

Model 2 $z_y = a_3 z_{x3} + E_2$

	z_{y1_1}	z_{x1_1}
s_1	z_{y1_2}	z_{x1_2}
	.	.
	.	.
	$z_{y1_{30}}$	$z_{x1_{30}}$
	z_{y1}	z_{x2_1}
	z_{y1_2}	z_{x2_2}
s_2	.	.
	.	.
	$z_{y1_{30}}$	$z_{x2_{30}}$

Results for Study One

Testing Model 1 against Model 2 will determine if $a_1 \neq a_2$. The testing of Model 1 against Model 2 should give the same results as one would get by using formula one, the z test.

Reported in Table 1 are F values obtained by testing Model 1 against Model 2 for the 100 pairs of samples drawn (F critical for $df_1 = 1$, $df_2 = 28$, $\alpha = .05 = 3.34$).

Only four of the F values computed when testing Model 1 against Model 2 exceeded the critical value or for this problem four times in a hundred a null hypothesis was rejected when alpha was set at .05.

When the z and F scores in Table 1 were compared, it was found that in 98 percent of the cases the same conclusion would have been drawn regarding the hypothesis $H_o: r_1 - r_2 = 0$. For two of the cases in which the F scores exceeded the critical value, this was also true of the z scores. Examination of cases 44 and 80 show the F scores exceeded the critical magnitude while the z scores narrowly failed to reach significance. (Critical z = 1.96, observed z scores were 1.88 and 1.86 respectively.)

Table 1

Comparison Data for Independent Samples Testing the Hypothesis that $r_1 - r_2 = 0$ Using MLR Vs Z Test

Sample	R_{12}	R_{13}	F	Z
1	-.0382	-.1445	.2275	.3906
2	.1097	-.0822	1.0266	.7051
3	.1659	.2998	.0562	-.4921
4	-.1066	-.0515	.0213	-.2024
5	.2092	.1476	.0341	.2264
6	-.2958	-.2087	.2870	-.3202
7	-.2195	-.2314	.0277	.0439
8	.1568	.1993	.0074	-.1563
9	-.0877	-.3084	.0018	.8110
10	.2246	-.4637	7.8551	2.5292
11	-.0876	.0219	.2493	-.4023
12	-.3548	-.0749	.8628	-1.0285
13	.0987	.1240	.0018	-.0932
14	-.2053	.0243	.7295	-.8433
15	-.1435	-.1563	.0075	.0473
16	-.0480	.1629	.5986	-.7749
17	.0000	-.1785	.6556	.6557
18	-.2496	.0925	1.8128	-1.2570
19	.1861	-.0689	.8114	.9370
20	-.1435	-.1249	.0067	-.0682

Table 1
(Continued)

Sample	R_{12}	R_{13}	F	Z
21	-.2176	-.3741	.2903	.5749
22	.0697	-.0965	.3642	.6106
23	.1512	-.0695	.7133	.8108
24	-.4703	-.2006	1.6368	-.9910
25	.0205	.1436	.2862	-.4523
26	-.1161	-.3024	.3117	.6844
27	.0474	-.0715	.1613	.4369
28	-.0955	-.2009	.2045	.3874
29	.1499	.0943	.0608	.2045
30	-.2011	.0636	1.0676	-.9725
31	.0724	-.2793	1.9379	1.2923
32	-.2372	-.3728	.1464	.4984
33	-.3727	-.1552	.9003	-.7990
34	-.0693	.1093	.4751	-.6564
35	-.1826	-.1275	.1153	-.2021
36	.2586	-.3983	7.2476	2.4136
37	.0553	.1837	.7674	-.4716
38	-.1205	-.1058	.0764	-.0540
39	-.1014	-.1708	.0305	.2550
40	-.1141	-.0091	.0876	-.3857
41	-.0957	.0036	.2218	-.3650
42	.1683	-.1274	1.4081	1.0867

(Continued)

nple	R_{12}	R_{13}	F	Z
3	.0874	.2461	.7123	-.5830
4	-.2835	.2293	4.6929	-1.8841
5	.0879	-.2377	1.8545	1.1964
6	-.2411	-.0628	.6567	-.6553
7	.0388	.1021	.0292	-.2326
8	-.0666	-.1132	.0020	.1710
9	-.1985	.0159	.6105	-.7879
0	-.1084	.3008	2.1849	-1.5033
1	-.1756	-.2217	.0206	.1692
2	-.2905	-.3968	.3242	.3905
3	-.2900	-.3334	.0202	.1592
4	-.0976	.0574	.3046	-.5696
5	-.3273	.0132	1.6870	-1.2510
6	-.0844	-.3070	.9242	.8181
7	-.1926	-.1973	.2412	.0175
8	.0219	.2391	1.3448	-.7980
9	-.2871	-.2601	.0793	-.0992
0	-.4133	-.2789	.2876	-.4938
1	.2297	.0214	.5132	.7654
2	-.2553	-.0265	.4226	-.8410
3	.0067	-.0732	.0108	.2935

Table 1
(Continued)

Sample	R_{12}	R_{13}	F	Z
64	-.1030	-.1145	.0104	.0424
65	-.1915	-.0339	.6764	-.5789
66	-.2034	-.1349	.0401	-.2517
67	-.1258	-.2431	.0679	.4310
68	-.3065	-.1268	.3624	-.6604
69	-.0125	-.1422	.2748	.4766
70	-.2968	.1366	2.6689	-1.5924
71	-.1137	-.1915	.0614	.2859
72	-.2050	-.1759	.0064	-.1069
73	-.0795	.0732	.2265	-.5611
74	.2440	-.2026	2.7359	1.6410
75	.1383	-.0037	.3197	.5215
76	.0074	-.0249	.0156	.1189
77	.0569	.0548	.0231	.0079
78	-.2532	-.3867	.4696	.4907
79	-.1658	.1182	.8270	-1.0434
80	-.3158	.1903	3.7560	-1.8594
81	-.2261	.0801	1.5966	-1.1251
82	-.2011	-.0749	.2890	-.4638
83	-.0156	.0234	.0150	-.1433
84	-.1663	-.0888	.1434	-.2845

Table 1
(Continued)

mple	R_{12}	R_{13}	F	Z
35	-.1278	.1714	.9152	-1.0993
36	-.1424	-.0176	.0748	-.4583
37	-.3278	.1275	3.1805	-1.6732
38	-.0852	.0105	.1551	-.3515
9	-.1290	-.0545	.1322	-.2736
0	-.0962	-.0521	.0419	-.1620
1	.0666	-.0978	.3745	.6041
2	-.1241	-.3654	.6108	.8869
3	.0000	-.1096	.7583	.4025
4	-.2129	.0429	.7594	-.9398
5	-.3984	.0154	1.8932	-1.5204
6	.0182	.1301	.0856	-.4111
7	.0736	.0088	.0604	.2383
8	-.2708	-.0433	1.1240	-.8360
9	.0142	-.1267	.3515	.5177
0	-.0968	-.1105	.0084	.0506

e: The F and Z values for the 100 samples were in agreement 98% of the time. Data for sample 44 and 80 showed the F with 1 and 28 df to be significant while the Z value narrowly fail to be significant. Critical value of F was 3.34.

Comparison of the Glass and Stanley Procedure (z test) to the Hinkle, Wiersma and Jurs Procedure (t test) to the Newman Procedure (MLR) in Testing the Hypothesis $H_o: r_1 - r_2 = 0$, $H_A\ r_1 - r_2 \neq 0$ $\alpha = .05$ for Dependent Sample Data.

Method for Study Two

Solution to the problem of testing for a significant difference between r_1 and r_2 when dependent samples are used must take into account the lack of orthogonality by including the degree of co-variance between the two samples in the error term of the test. Results of solving this problem using the three procedures referred to will be reported below.

A Monte Carlo procedure was used to draw 100 pairs of dependent samples. Correlations were run between similar predictor (X) and criterion (Y) variables in each sample (r_1 and r_2). The criterion variable (Y) was the dichotomous variable sex. Predictor variables were GPA (X_1) and reading achievement (X_2). All data were obtained from the Coleman Data Bank.

Formula 2, presented below, is the solution suggested by Glass and Stanley, 1970.

Formula 2

$$z = \frac{N(r_{xy} - r_{x2})}{\sqrt{(1-r^2_{xy})^2 + (1 - r^2_{xz})^2 - 2r^3_{yz} - (2r_{yz} - r_{xy}r_{xz}) \\ (1 - r_{xy} - r^2_{xz} - r^2_{yz})}}$$

Inspection of z scores obtained using Formula 2 and reported in Table 2 indicate that two of the 100 tests reached the critical value of 1.96. Thus, in only two cases was the null hypothesis rejected.

Formula 3 presented below is the solution suggested by Hinkle, Wiersma and Jurs, 1979.

Formula 3

$$t = \frac{(r_{xy} - r_{x2})\sqrt{(n - 3)(1 + r_{yz})}}{\sqrt{2(1 - r^2_{xy} - r^2_{xz} - r^2_{yz} + 2r_{xy}r_{xz}r_{yz})}}$$

Inspection of t scores obtained by using Formula 3 and reported in Table 2 indicates that two of the 100 tests reached the critical value of 2.00 with df = 57. Thus, in only two cases was the null hypothesis rejected.

The MLR procedure used to test for a significant difference between r_1 and r_2 obtained from dependent samples involved the transformation of predictor and criterion variables into standard scores in order to obtain common units of measurements. The hypothesis that $H_o: a_1 = a_2 = a_3$ (a_3 represents the common slope) was tested by comparing the amount of variance accounted for by the following regression models. Values a_1, a_2, a_3 are partial regression weights.

Full Model 3 VS Restricted Model 4

Theoretical Models 3 and 4

$$z_y = a_1 z_{x1} + a_2 z_{x2} + a_4 p_1 + \ldots + a_{60} p_{63} + E_3$$

VS

$$z_y = a_3 z_{x3} + a_4 p_1 + \ldots a_{63} p_{60} + E_4$$

Peddhazur's conceptual approach for Models 3 and 4 where small ps are collapsed and designated as a large P. (See Peddhazur, 1977; Williams, 1977.)

$$z_y = a_1 z_{x1} + a_2 z_{x2} + a_4 P + E_3 \text{ VS } z_y = a_3 z_{x3} + a_4 P + E_4$$

(In standard score form z_{x1} represents GPA in sample 1 (s_1) z_{x2} represents reading achievement for the same persons in sample 2 (s_2), z_{x3} represents the predictor score regardless if the score came from sample 1 or 2; $z_{x3} = z_{x1} + z_{x2}$ and z_y represents the criterion variable sex; a_4 is a partial regression weight; Ps represent person vectors used to account for the co-variance between the two dependent samples; a_3 represents the common slope for the partial regression weights a_1 and a_2.)

Below is a simulated numerical example to explain the procedure.

Full Model 3

Model 3		z_y =	$a_1 z_{x1}$ +	$a_2 z_{x2}$ +	a_4 P + E_3
Sub.	1	1	1	0	2.5
	2	1	.5	0	1.2
s_1	3	0	-.3	0	-.5
	4	0	.7	0	1.6

Sub.	1	0	0	1.5	2.5
	2	0	0	.7	1.2
s_2	3	1	0	-.2	-.5
	4	1	0	.9	1.6

Restricted Model 4

Restriction $a_1 = a_2 = a_3$

Model 4 $z_y = a_3 z_{x3} + a_4 P + E_4$

Sub.	1	1	1	2.5
	2	1	.5	1.2
s_1	3	0	-.3	-.5
	4	0	.7	1.6
Sub.	1	0	1.5	2.5
	2	0	.7	1.2
s_2	3	1	-.2	-.5
	4	1	.9	1.6

Attention is directed to the procedure used to develop the person vectors. Model 3 represents the prediction of sex (z_y) by the standardized GPA (z_{x1}), the standardized reading achievement score (z_{x2}) and a composite person vector (P). In the simulated model there are four subjects, two males and two females, each of whom is measured twice; once on GPA and once on reading achievement. The person vector is then computed by adding the GPA score of subject 1 to the reading achievement score of subject 1; which in the simulated case sums to 2.5. Similarly for subject 2 one adds GPA to reading achievement and places the total 1.2 in the two positions of the person vector representing subject 2. This procedure is repeated until all persons are represented by a person vector, thus accounting for the covariance between the dependent samples.

Results for Study Two

Reported in Table 2 are F values obtained by testing Model 3 against Model 4 for the 100 samples drawn (F critical for $df_1 = 2$, $df_2 = 57$, $\alpha \doteq .05$ is 3.17). Only two of the F values computed exceeded the critical value. Thus, for only two cases was the null hypothesis rejected with alpha set at .05.

When the z, t and F scores reported in Table 2 were compared, it was found that for the same two cases (58 and 62) the z, t and F test results were significant. It is, therefore, apparent that there was 100 percent agreement among the three procedures used.

Conclusion

To the extent that the approaches suggested by Minium, 1978; Glass and Stanley, 1970; Hinkle, Wiersma and Jurs, 1979 are valid, the use of multiple linear regression has been demonstrated to be a viable procedure for testing for a significant difference between r_1 and r_2 with both dependent and independent data. Results using MLR were in

Table 2

Comparison Data for Dependent Samples Testing the Hypothesis that $r_1 - r_2 = 0$ Using MLR (F) Vs the Z Test Vs the t Test

Sample	R_{12}	R_{13}	R_{23}	F	Z	t
1	-.1081	-.1019	-.5947	.0141	-.0273	-.0271
2	-.0049	-.0730	-.4437	.0600	.3109	.3033
3	-.0685	-.1147	-.4848	.0200	.2094	.2059
4	-.2429	.1196	-.4731	2.0612	-1.7047	-1.6438
5	-.0427	-.1308	-.3334	.1386	.4213	.4125
6	-.2337	-.0451	-.5143	.5423	-.8629	-.8587
7	-.1578	-.1723	-.4318	.0002	.0680	.0680
8	-.1443	-.0763	-.4686	.1262	-.3113	-.3071
9	-.1229	-.2118	-.4150	.1868	.4203	.4201
10	-.0698	-.1742	-.5636	.0899	.4648	.4625
11	.0388	-.2175	-.5485	.9222	1.1573	1.1320
12	-.2294	.1421	-.5152	2.1572	-1.7221	-1.6558
13	-.0391	-.0373	-.5848	.0003	-.0080	-.0078
14	-.2290	-.0820	-.0279	.1535	-.8143	-.7983
15	-.0909	-.0583	-.5034	.0285	-.1466	-.1438
16	-.0975	-.1126	-.3899	.0074	.0709	.0697
17	-.1112	-.0085	-.4717	.2554	-.4666	-.4559
18	-.0344	.0036	-.4687	.0137	-.1719	-.1675
19	.0208	-.0351	-.6242	.0499	.2406	.2344

Table 2

(Continued)

Sample	R_{12}	R_{13}	R_{23}	F	Z	t
20	-.1637	.0648	-.6433	.6383	-.9927	-.9661
21	-.1286	-.0124	-.5309	.1273	-.5187	-.5079
22	.1160	-.1413	-.3697	.9576	1.2280	1.1886
23	-.1486	-.2208	-.3999	.1420	.3449	.3464
24	-.0933	.0405	-.5993	.2844	-.5828	-.5674
25	-.1714	.0376	-.5277	.5597	-.9417	-.9184
26	.1634	-.1349	-.5247	1.2434	1.3573	1.3096
27	-.1369	.0733	-.2734	.6172	-1.0346	-1.0046
28	.0417	-.1020	-.4548	.2704	.6571	.6395
29	.0000	-.0934	-.3753	.0726	.4381	.4273
30	.0378	.2072	-.3869	.4074	-.8049	-.7919
31	-.1102	.2080	-.4317	1.5068	-1.5030	-1.4518
32	-.1122	.0247	-.3253	.3005	-.6559	-.6389
33	-.1519	.0089	-.5131	.2809	-.7245	-.7084
34	-.1304	.1154	-.5743	.8748	-1.0910	-1.0559
35	.1613	-.2518	-.5863	2.4361	1.8883	1.8093
36	-.2672	.1156	-.4620	2.2825	-1.8183	-1.7541
37	-.1817	.1420	-.6488	1.5265	-1.4215	-1.3691
38	-.2039	-.2760	-.3791	.3468	.3548	.3639
39	-.1299	-.1480	-.3844	.0000	.0858	.0849
40	.0268	-.2342	-.4445	1.0715	1.2244	1.1973

(Continued)

Sample	R_{12}	R_{13}	R_{23}	F	Z	t
41	-.0862	.0675	-.5479	.3316	.6814	-.6624
42	-.1134	-.1388	-.3589	.0068	.1214	.1197
43	-.1972	-.0269	-.5492	.4731	.7643	.7557
44	.0722	-.1105	-.4592	.5056	.8365	.8126
45	.1039	-.0568	-.4406	.3424	.7391	.7186
46	-.1462	.0208	-.5723	.3459	-.7379	-.7210
47	-.1396	.0224	-.4709	.3753	-.7395	-.7212
48	-.1728	-.1842	-.6266	.0000	.0502	.0521
49	-.1147	-.0868	-.5359	.0033	-.1245	-.1230
50	.0794	.0287	-.5166	.0303	.2263	.2212
51	-.0849	-.0789	-.3848	.0007	-.0280	-.0274
52	-.1164	-.1037	-.4168	.0085	-.0591	-.0582
53	-.1752	-.0219	-.5276	.2925	-.6898	-.6789
54	-.2124	-.0444	-.4226	.4027	-.7889	-.7785
55	.0896	-.0502	-.3565	.2555	.6618	.6439
56	.1172	-.2122	-.5267	1.5152	1.5087	1.4563
57	-.1864	.1915	-.6415	2.0257	-1.6806	-1.6098
58	-.4106	.0709	-.4124	4.1282	-2.4361	-2.3888
59	-.0425	-.0898	-.3059	.0451	.2278	.2226
60	.0822	-.1186	-.5032	.6037	.9077	.8809
61	-.2270	.0985	-.3751	1.5038	-1.5736	-1.5216
62	-.1543	.3160	-.6016	3.6028	-2.1797	-2.0931

Table 2

(Continued)

Sample	R_{12}	R_{13}	R_{23}	F	Z	t
63	.0251	-.1084	-.4283	.2451	.6155	.5996
64	-.2392	-.0805	-.3373	.3583	-.7738	-.7665
65	-.2249	-.2041	-.4498	.0027	-.0986	-.1010
66	-.1786	-.0302	-.2974	.4226	-.7250	-.7099
67	-.1096	.1093	-.3481	.6796	-1.0474	-1.0157
68	-.0522	.0362	-.4824	.1157	-.3990	-.3885
69	-.1247	.1739	-.3957	1.3316	-1.4216	-1.3729
70	.0057	-.1372	-.6823	.3335	.6094	.5983
71	-.1623	.1125	-.3261	1.0284	-1.3374	-1.2939
72	-.1065	-.1328	-.4727	.0680	.1202	.1190
73	.0209	.0120	-.4677	.0018	.0405	.0395
74	-.2765	-.0479	-.3575	.5527	-1.1157	-1.1045
75	.1378	-.0768	-.3822	.7065	1.0143	.9844
76	-.0664	-.1420	-.3096	.1457	.3661	.3591
77	-.1462	-.1286	-.3292	.0466	-.0850	-.0840
78	-.2009	-.0959	-.5044	.3175	-.4800	-.4800
79	-.0960	-.2412	-.2796	.1335	.7244	.7171
80	-.1449	.0812	-.4936	.7979	-1.0293	-.9985
81	-.1217	-.1347	-.4893	.0955	.0591	.0587
82	-.0315	-.2108	-.5069	.3846	.8179	.8087
83	-.1265	.0388	-.4502	.4362	-.7589	-.7388
84	-.1869	.1276	-.5317	1.4378	-1.4325	-1.3818

Table 2

(Continued)

Sample	R_{12}	R_{13}	R_{23}	F	Z	t
85	-.1404	.0383	-.6209	.5040	-.7773	-.7583
86	-.1376	-.0578	-.4992	.1262	-.3607	-.3552
87	-.2128	.1423	-.4939	1.7676	-1.6518	-1.5890
88	-.1787	-.0716	-.5486	.0233	-.4796	-.4772
89	-.0400	-.0773	-.6466	.0179	.1600	.1570
90	-.0700	.0425	-.5035	.1760	-.5043	-.4909
91	-.0341	-.2049	-.5194	.3524	.7750	.7667
92	-.0233	-.2465	-.4014	1.0884	1.0644	1.0487
93	-.0624	-.0942	-.3143	.0317	.1524	.1491
94	.1593	-.0670	-.5301	.7893	1.0181	.9892
95	-.1582	-.1596	-.3849	.0001	.0067	.0067
96	.0196	-.3220	-.6075	2.6945	1.5569	1.5625
97	-.2074	.0764	-.4796	1.1570	-1.3129	-1.2740
98	-.0962	-.0658	-.5215	.0722	-.1357	-.1334
99	-.1564	.0108	-.5323	.3164	-.7495	-.7332
100	-.2481	.0265	-.4969	.9063	-1.2694	-1.2449

Note: The F, Z and t values for the 100 samples were in agreement 100% of the time. Degrees of freedom for the F and t values were $F_1 = 2$, $F_2 = 57$ and $df_t = 57$. The critical value of F was 3.17 for t it was 2.00.

98 percent agreement with the procedure suggested by Minium (1978) for dependent data. For the two cases (44 and 80) where the MLR results did not agree with the more traditional procedure, the observed values just missed reaching the critical level, 1.88 and 1.86 respectively. When data from dependent samples were evaluated, there was 100 percent agreement among the procedures suggested by Glass and Stanley, 1970 (z test); Hinkle, Wiersma and Jurs, 1979 (t-test); and Newman (MLR).

The similarity in the results tends to support the use of all procedures tested. The writers, however, found the traditional tests (z and t) to be more cumbersome when a computer program for testing general linear models was available. In addition to the pragmatic consideration, a pedagogical advantage seems to exist when using MLR. Teaching students how to use the general linear model permits them to conceptualize more clearly what they are doing. This would be especially true for more naive students for whom application of the traditional models may be based entirely upon what appears to be unrealted statistical procedures. For the more sophisticated individual, MLR facilitates expression of the research question of interest in terms of general linear models without having to worry about a specific procedure to use for that particular problem.

Further, it is the belief of the authors that the general linear model approach to testing hypotheses is more apt to increase the ability of the researchers to ask questions that are of most specific interest to them; reducing the likelihood of their making a Type VI Error, Newman, I.; Deitchman, R.; Burkholder, J.; Sanders, P.; and Ervin, L. (1976) and Roll, S.; Hoedt, K.; and Newman, I. (1979). A Type VI Error is the inconsistency between the research question of interest and the statistical model being applied.

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