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TITLE	NON-PARAMETRICS: THE MANN-WHITNEY U TEST AND THE WILCOXON MATCHED-PAIRS SIGN-RANKS TEST
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NON-PARAMETRICS: THE MANN-WHITNEY U TEST AND THE WILCOXON MATCHED-PAIRS SIGN-RANKS TEST

DECUS Program Library Write-up

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The Mann-Whitney U program computes the U or the U' statistics and gives the N of the two groups. The Wilcoxon Matched-Pairs Sign-Ranks Test computes the z score and N. Once either program is loaded the computer requests information.

The Programs

The Mann-Whitney U Test is the alternative to the parametric t test for independent samples when the data do not meet the assumptions of the parametric t test or when the data is not of an interval scaling. The Wilcoxon Matched-Pairs Sign-Ranks Test is similar to the parametric t test for correlated samples. The Wilcoxon Matched-Pairs Sign-Ranks Test takes into account magnitude as well as direction of differences between matched pairs. The test gives more weight to a pair which shows a large difference between the two conditions than to a pair which shows small differences.

Mann-Whitney U Test

INPUT: After the program is loaded the computer will ask:

SS/group: This is a request for the number of subjects in the two groups. Type in a number of subjects for the first group and then a space and again the number and a space for the second group. The computer will then print DATA and

GRP1: Type in the data. After each datam there must be a space. The data can either be ranks or raw data. Prior ranking does not save time. After the data for the first group have been entered the computer will request data for the second group.

OUTPUT: The computer will give the Mann-Whitney U and the number of subjects in each group.

The significance levels for the U can be found in Siegel, 1956.

Wilcoxon Matched-Pairs Signed-Ranks Test

INPUT: After the program is loaded the computer will ask:

NO.SS

IN GROUP: This is a request for the number of subjects for the group. Type in the number of subjects and then a space. The computer will then print:

ENTER DATA: The pairs of each group should be entered in order at this time.

OUTPUT: The computer will give z score and the N. Ties will have been taken into account. The significance of the z score can be found in Siegel, 1956, Table A.

Statistical Techniques (from Siegel, 1956).

The Mann-Whitney U is derived from the formula $U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$ where R_1 equals the sum of ranks assigned to the group whose sample size is R_1. The program accounts for tied scores by assigning the tied observations the average ranks they would have had if no ties had occurred.

The Wilcoxon Matched-Pairs Signed-Ranks Test

The statistic z is derived from the formula

$$z = \frac{T - \frac{N(N+1)}{4}}{\sqrt{\frac{N(N+1)(2N+1)}{24}}}$$

where T = the smaller sum of the signed ranks (either positive or negative).

REFERENCES

Siegal, S. Non-parametric statistics for the behavioral sciences, New York, McGraw-Hill, 1956.

MANN-WHITNEY U TEST
C-FOCAL , 8/68

```
01.10 ERASE
01.20 T "SS/GROUP"
01.30 A N1,N2;IF (20-N1)1.36;IF (20-N2)1.36;IF (N2-N1)1.34,1.4,1.4
01.34 T "N1 MUST BE LESS THAN N2",!!;GOTO 1.1
01.36 T "NOT WITHIN LIMITS",!!;GOTO 1.1
01.40 T !!!,"DATA",!!,"GRP 1",!
01.50 FOR J=1,1,N1;ASK A(J);S G(J)=1
01.55 T !!,"GRP 2",!;S I=N1+1;S N=N1+N2
01.60 FOR J=I,1,N;ASK A(J);S G(J)=2
01.70 S I=N-1;T !!,"WAIT",!!
01.71 DO 1.72
01.72 S CH=0;DO 1.73;IF (CH)2.1,2.1,1.71
01.73 FOR J=1,1,I;DO 2

02.01 S IT=A(J);S K2=G(J)
02.02 IF (IT-A(J+1))2.05,2.05,2.03
02.03 S CH=CH+1;S A(J)=A(J+1);S G(J)=G(J+1)
02.04 S A(J+1)=IT;S G(J+1)=K2
02.05 RETURN
02.10 S IT=0;S IC=0;S A(N+1)=999
02.11 FOR J=1,1,N;DO 3
02.12 GOTO 3.1

03.01 IF (A(J)-A(J+1))3.03,3.02,3.03
03.02 S IT=IT+1;S IC=IC+J;GOTO 3.08
03.03 IF (IT)3.07,3.07,3.04
03.04 S IC=IC+J;S IT=IT+1;S CH=IC/IT
03.05 S K2=(J-IT)+1;FOR I=K2,1,J;S A(I)=CH
03.06 S IC=0;S IT=0;GOTO 3.08
03.07 S A(J)=J
03.08 RETURN
03.10 S I=0;S IT=0;S IC=0
03.12 S I=I+1;IF (I-N)3.13,3.13,3.15
03.13 IF (G(I)-1)3.12,3.14,3.12
03.14 S IC=IC+A(I);S IT=IT+1;IF (IT-N1)3.12,3.12
03.15 S I=N1*N2;S IT=((N1+1)*N1)/2
03.16 S CH=(I+IT)-IC;S K2=I-CH
03.17 IF (CH-K2)3.18,3.19,3.19
03.18 T "U ";T %10.4,CH,!;GOTO 3.2
03.19 T "U'";T %10.4,K2,!
03.20 T "N1";T %3,N1;T "    N2";T %3,N2,!!
03.21 QUIT
*
```

```
*G
SS/GROUP:4 :5

DATA

GRP 1
:110 :70 :53 :51

GRP 2
:78 :64 :75 :45 :82

WAIT

U'= 9.000000000
N1=    4    N2=    5

*
```

C-FOCAL., 1968

```
01.10 ERASE
01.20 A "NO SS IN GROUP",N
01.30 T !!!;"ENTER DATA",!!
01.40 FOR J=1,1,N; ASK A(J),B(J);T !
01.50 FOR J=1,1,N;S A(J)=B(J)-A(J);S B(J)=FABS(A(J));S G(J)=J

02.10 S I=N-1;T !!!
02.15 T "WAIT PATIENTLY",!!!
02.20 DO 2.3
02.30 S CH=0;DO 2.4;IF (CH)4.1,4.1,2.2
02.40 FOR J=1,1,I;DO 3

03.10 S TS=B(J);S K2=G(J)
03.20 IF (TS-B(J+1))3.5,3.5,3.3
03.30 S CH=CH+1;S B(J)=B(J+1);S G(J)=G(J+1)
03.40 S B(J+1)=TS;S G(J+1)=K2
03.50 RETURN

04.10 S K2=N;S K=0;S IT=0;S IC=0;S TS=0
04.11 S K=K+1;IF (K-N)4.12,4.12,4.20
04.12 IF (B(K))4.13,4.13,4.20
04.13 S K2=K2-1;GOTO 4.11
04.20 S B(N+1)=999;FOR J=K,1,N;DO 5
04.30 GOTO 6.1

05.05 S Z=J;S TS=TS+1
05.10 IF (B(J)-B(J+1))5.3,5.2,5.3
05.20 S IT=IT+1;S IC=IC+TS;GOTO 5.8
05.30 IF (IT)5.7,5.7,5.4
05.40 S IC=IC+TS;S IT=IT+1;S CH=IC/IT
05.50 S K2=(J-IT)+1;FOR I=K2,1,Z;S RN(I)=CH
05.60 S IC=0;S IT=0;GOTO 5.8
05.70 S RN(J)=TS
05.80 RETURN

06.10 S IC=0;S IT=0;S J=0;S K=0;S Z=N
06.20 FOR I=1,1,N;DO 7
06.30 GOTO 8.1

07.10 S K2=G(I);IF (A(K2))7.2,7.4,7.3
07.20 S IC=IC+1;S J=J+RN(I);GOTO 7.5
07.30 S IT=IT+1; S K=K+RN(I);GOTO 7.5
07.40 S Z=Z-1
07.50 RETURN

08.10 S N=Z;S CH=(N*(N+1))/4
08.20 S TS=FSQT(((N*(N+1))*((2*N)+1))/24)
08.30 IF (IC-IT)8.4,8.4,8.5
08.40 S Z=(J-CH)/TS;GOTO 8.6
08.50 S Z=(K-CH)/TS
08.60 T "Z-SCORE";T %10.6,Z,!
08.70 T "N"; T %3,N,!!!
08.80 QUIT
*
```

```
*G
NO SS IN GROUP:14

ENTER DATA

:24 :24
:150 :145
:135 :138
:42 :42
:102 :121
:96 :115
:33 :33
:127 :134
:118 :132
:132 :138
:38 :38
:124 :145
:115 :126
:103 :94


WAIT PATIENTLY


Z-SCORE=-2.089550000
N=+ 10

*
```

MANN-WHITNEY U TEST
C-FOCAL , 8/68

```
01.10 ERASE
01.20 T "SS/GROUP"
01.30 A N1,N2;IF (20-N1)1.36;IF (20-N2)1.36;IF (N2-N1)1.34,1.4,1.4
01.34 T "N1 MUST BE LESS THAN N2",!!;GOTO 1.1
01.36 T "NOT WITHIN LIMITS",!!;GOTO 1.1
01.40 T !!!,"DATA",!!,"GRP 1",!
01.50 FOR J=1,1,N1;ASK A(J);S G(J)=1
01.55 T !!,"GRP 2",!;S I=N1+1;S N=N1+N2
01.60 FOR J=I,1,N;ASK A(J);S G(J)=2
01.70 S I=N-1;T !!,"WAIT",!!
01.71 DO 1.72
01.72 S CH=0;DO 1.73;IF (CH)2.1,2.1,1.71
01.73 FOR J=1,1,I;DO 2

02.01 S IT=A(J);S K2=G(J)
02.02 IF (IT-A(J+1))2.05,2.05,2.03
02.03 S CH=CH+1;S A(J)=A(J+1);S G(J)=G(J+1)
02.04 S A(J+1)=IT;S G(J+1)=K2
02.05 RETURN
02.10 S IT=0;S IC=0;S A(N+1)=999
02.11 FOR J=1,1,N;DO 3
02.12 GOTO 3.1

03.01 IF (A(J)-A(J+1))3.03,3.02,3.03
03.02 S IT=IT+1;S IC=IC+J;GOTO 3.08
03.03 IF (IT)3.07,3.07,3.04
03.04 S IC=IC+J;S IT=IT+1;S CH=IC/IT
03.05 S K2=(J-IT)+1;FOR I=K2,1,J;S A(I)=CH
03.06 S IC=0;S IT=0;GOTO 3.08
03.07 S A(J)=J
03.08 RETURN
03.10 S I=0;S IT=0;S IC=0
03.12 S I=I+1;IF (I-N)3.13,3.13,3.15
03.13 IF (G(I)-1)3.12,3.14,3.12
03.14 S IC=IC+A(I);S IT=IT+1;IF (IT-N1)3.12,3.12
03.15 S I=N1*N2;S IT=((N1+1)*N1)/2
03.16 S CH=(I+IT)-IC;S K2=I-CH
03.17 IF (CH-K2)3.18,3.19,3.19
03.18 T "U ";T %10.4,CH,!;GOTO 3.2
03.19 T "U'";T %10.4,K2,!
03.20 T "N1";T %3,N1;T "   N2";T %3,N2,!!
03.21 QUIT
*
```

```
*G
SS/GROUP:4 :5

DATA

GRP 1
:110 :70 :53 :51

GRP 2
:78 :64 :75 :45 :82

WAIT

U'= 9.000000000
N1=    4    N2=    5

*
```

WILCOXON MATCHED-PAIR SIGNED-RANK TEST

C-FOCAL., 1968

```
01.10 ERASE
01.20 A "NO SS IN GROUP",N
01.30 T !!!,"ENTER DATA",!!
01.40 FOR J=1,1,N; ASK A(J),B(J);T !
01.50 FOR J=1,1,N;S A(J)=B(J)-A(J);S B(J)=FABS(A(J));S G(J)=J

02.10 S I=N-1;T !!!
02.15 T "WAIT PATIENTLY",!!!
02.20 DO 2.3
02.30 S CH=0;DO 2.4;IF (CH)4.1,4.1,2.2
02.40 FOR J=1,1,I;DO 3

03.10 S TS=B(J);S K2=G(J)
03.20 IF (TS-B(J+1))3.5,3.5,3.3
03.30 S CH=CH+1;S B(J)=B(J+1);S G(J)=G(J+1)
03.40 S B(J+1)=TS;S G(J+1)=K2
03.50 RETURN

04.10 S K2=N;S K=0;S IT=0;S IC=0;S TS=0
04.11 S K=K+1;IF (K-N)4.12,4.12,4.20
04.12 IF (B(K))4.13,4.13,4.20
04.13 S K2=K2-1;GOTO 4.11
04.20 S B(N+1)=999;FOR J=K,1,N;DO 5
04.30 GOTO 6.1

05.05 S Z=J;S TS=TS+1
05.10 IF (B(J)-B(J+1))5.3,5.2,5.3
05.20 S IT=IT+1;S IC=IC+TS;GOTO 5.8
05.30 IF (IT)5.7,5.7,5.4
05.40 S IC=IC+TS;S IT=IT+1;S CH=IC/IT
05.50 S K2=(J-IT)+1;FOR I=K2,1,Z;S RN(I)=CH
05.60 S IC=0;S IT=0;GOTO 5.8
05.70 S RN(J)=TS
05.80 RETURN

06.10 S IC=0;S IT=0;S J=0;S K=0;S Z=N
06.20 FOR I=1,1,N;DO 7
06.30 GOTO 8.1

07.10 S K2=G(I);IF (A(K2))7.2,7.4,7.3
07.20 S IC=IC+1;S J=J+RN(I);GOTO 7.5
07.30 S IT=IT+1; S K=K+RN(I);GOTO 7.5
07.40 S Z=Z-1
07.50 RETURN

08.10 S N=Z;S CH=(N*(N+1))/4
08.20 S TS=FSQT(((N*(N+1))*((2*N)+1))/24)
08.30 IF (IC-IT)8.4,8.4,8.5
08.40 S Z=(J-CH)/TS;GOTO 8.6
08.50 S Z=(K-CH)/TS
08.60 T "Z-SCORE";T %10.6,Z,!
08.70 T "N"; T %3,N,!!!
08.80 QUIT
*
```

```
*G
NO SS IN GROUP:14

ENTER DATA

:24 :24
:150 :145
:135 :138
:42 :42
:102 :121
:96 :115
:33 :33
:127 :134
:118 :132
:132 :138
:38 :38
:124 :145
:115 :126
:103 :94


WAIT PATIENTLY


Z-SCORE=-2.089550000
N=+ 10
```