A FORTRAN 77 program for averaging correlation coefficients

N. CLAYTON SILVER

and SARAH C. HOLLINGSWORTH

Appalachian State University, Boone, North Carolina

Because the correlation coefficient is extremely variable, it is often recommended that large samples be used to obtain stable estimates of the population correlation. When small sample sizes are repeatedly tested (Carter, Kennedy, & Bittner, 1981; Mackaman, Bittner, Harberson, Kennedy, & Stone, 1982), however, it has been shown that estimates of the population correlation become more stable when correlations are averaged over these measures (see Dunlap, Jones, & Bittner, 1983; Dunlap, Silver, & Bittner, 1986; Dunlap, Silver, Hunter, & Bittner, 1985).

A number of different methods for averaging correlations have been studied. Silver and Dunlap (1987) found that the backtransformed average z produced more accurate estimates of the population correlation than did the arithmetic average r when the sample sizes were small and the population correlation exceeded .5. Furthermore, Dunlap, Silver, and Phelps (1988) found that the backtransformed average z was less biased and had greater precision than did a procedure proposed by Kaiser (1968), which used the first eigenvalue in an intercorrelation matrix, particularly when sample sizes were small.

The backtransformed average z procedure for averaging correlations involves transforming each correlation to Fisher's z (1921), which distributes approximately normal, where

$$z = 0.5 \log_e [(1+r)/(1-r)]. \quad (1)$$

The Fisher z s are averaged by the following equation (cf. Fisher, 1973; Lindeman, Merenda, & Gold, 1980):

$$z_{av} = \frac{(n_1-3)z_1 + (n_2-3)z_2 + \dots + (n_k-3)z_k}{n_1 + n_2 + \dots + n_k - 3k}, \quad (2)$$

where n is the sample size for a particular correlation and k is the number of correlations. When the sample sizes for each correlation in the matrix are equal, this equation reduces to

$$z_{av} = (z_1 + z_2 + \dots + z_k)/k, \quad (3)$$

where k is the number of correlations. After the Fisher z s have been averaged, the average z is backtransformed to r via the following equation:

$$r = (e^{2z} - 1)/(e^{2z} + 1). \quad (4)$$

Furthermore, there are instances when one can test the null hypothesis that $\bar{r} = 0$ (cf. Fisher, 1973; Lindeman et al., 1980). To test this hypothesis, the following equation is used (cf. Fisher, 1973; Lindeman et al., 1980):

$$z = z_{av} \sqrt{n_1 + n_2 + \dots + n_k - 3k}. \quad (5)$$

The program. The user is prompted interactively for the number of correlations. This should be the number of correlations on the upper or lower half of the matrix excluding the diagonal. Next, the user is asked if the sample size is equal for each correlation in the matrix. If the sample size is equal for each correlation, the program converts each correlation to Fisher's z , sums up the Fisher z s, and divides by the number of correlations the user had input. Next, the average z is backtransformed to average r . If the sample size is not equal, then a weighted average of Fisher z s is computed (see Equation 2). This weighted average is backtransformed to average r . The program then computes the test of the null hypothesis that $\bar{r} = 0$. The output consists of the backtransformed average z , the z value from the significance test, and the probability of rejecting the null hypothesis of $\bar{r} = 0$ using the function ZPRB (Dunlap & Duffy, 1975).

Requirements. The program is written in single precision FORTRAN 77 and runs on a VAX 8550 computer. Because the program is interactive, the input and output are via the terminal. There are no nonstandard FORTRAN statements, however, users might have to substitute a format statement number for the free format symbol "*" in the READ statement on some systems. Also, Unit 5 has been assigned by default to the keyboard and CRT screen on our system.

Availability. A listing of the program may be obtained at no charge from N. Clayton Silver.

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Correspondence may be addressed to N. Clayton Silver, Department of Psychology, Appalachian State University, Boone, NC 28608.

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APPENDIX

**FORTRAN 77 Program for Averaging Correlations and Testing the
Average Correlation for Significance**

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C THIS PROGRAM COMPUTES AN AVERAGE CORRELATION USING THE
C BACKTRANSFORMED AVERAGE FISHER'S Z AND TESTS THE AVERAGE
C CORRELATION FOR SIGNIFICANCE ( $H_0: \bar{r} = 0$ )
C
C
C      DIMENSION R(100), Z(100), XN(100)
C
C      CHARACTER A*1
C
C      OPEN(UNIT=2,FILE='AVCOR.OUT',STATUS='NEW')
C
C INITIALIZE VARIABLES
C
C
1      AL=0.0
      ALPHA=0.0
      AVZ=0.0
      AZ=0.0
      AZZ=0.0
      EE=0.0
      NCOR=0.0
      XAV=0.0
      XCOR=0.0
      XNSUM=0.0
      XS=0.0
      XSN=0.0
      ZAV=0.0
      ZDEN=0.0
      ZNUM=0.0
      ZSIG=0.0
C
C      WRITE(5,2)
2      FORMAT(/' HOW MANY CORRELATIONS DO YOU WANT TO
+ AVERAGE? ENTER 0 TO QUIT')
      READ(5,*)NCOR
      IF(NCOR.EQ.0)GO TO 13
      XCOR=NCOR
      WRITE(5,3)
3      FORMAT(' DO YOU HAVE EQUAL SAMPLE SIZE?')
      READ(5,4)A
4      FORMAT(A1)
      IF(A.EQ.'Y')GO TO 7
      DO 6 I=1,NCOR
      WRITE(5,5)
5      FORMAT(' ENTER YOUR SAMPLE SIZE AND CORRELATION')
      READ(5,*)XN(I),R(I)
      XS=XN(I)-3.
      Z(I)=0.5*ALOG((1.+R(I))/(1.-R(I)))
      XAV=XS*Z(I)
      ZNUM=ZNUM+XAV
      XNSUM=XNSUM+XN(I)
      ZDEN=XNSUM-(3*XCOR)
      ZAV=ZNUM/ZDEN

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APPENDIX (Continued)

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C
C BACKTRANSFORM TO R
C
      EE=EXP(2*ZAV)
      AZZ=(EE-1.)/(EE+1.)
C
C CALCULATE SIGNIFICANCE TEST
C
      ZSIG=ZAV*SQRT(ZDEN)
C
C CONTINUE
C GO TO 11
C
C WRITE(5,8)
C FORMAT( ' ENTER YOUR SAMPLE SIZE')
C READ(5,*)XSN
C
C DO 10 I=1,NCOR
C WRITE(5,9)
C 9 FORMAT(' ENTER YOUR CORRELATIONS')
C READ(5,*)R(I)
C Z(I)=0.5*ALOG((1.+R(I))/(1.-R(I)))
C AZ=AZ+Z(I)
C AVZ=AZ/XCOR
C 10 CONTINUE
C
C BACKTRANSFORM TO R (EQUAL SAMPLE SIZE)
C
      EE=EXP(2.*AVZ)
      AZZ=(EE-1.)/(EE+1.)
C
C SIGNIFICANCE TEST FOR EQUAL N
C
      ZSIG=AVZ*SQRT((XSN*XCOR)-(3*XCOR))
C
C 11 AL=ZPRB(ZSIG)
C ALPHA=AL*2
C
C WRITE(2,12)AZZ,ZSIG,ALPHA
C WRITE(5,12)AZZ,ZSIG,ALPHA
C 12 FORMAT(' THE AVERAGE CORRELATION = ',F8.4,
+ ' WITH A Z =', F8.4, ' AND A P =', F8.4)
C GO TO 1
C 13 WRITE(5,14)
C 14 FORMAT(' A SUMMARY IS CONTAINED IN AVCOR.OUT')
C STOP
C END
C
C -----
C
C FUNCTION ZPRB( XZ )
C
C COMPUTES THE CUMULATIVE PROBABILITY OF NORMAL
C DEVIATE Z
C ( INTEGRAL OF THE NORMAL DISTRIBUTION FROM Z TO
C INFINITY )
C
C IMPLICIT DOUBLE PRECISION ( A-H, O-Z )
C
C REAL XZ, ZPRB
C
C Z = DBLE( XZ )
C X = DABS( Z )
C Q = 39894228.0D-8 * DEXP( -X * X / 2.0D0 )

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APPENDIX (Continued)

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      IF( X .GT. 3.7D0 ) GO TO 1
      T = 1.0D0 / ( 1.0D0 + 2316419.0D-7 * X )
      P = 31938153.0D-8 * T
      P = P - 356563782.0D-9 * T**2
      P = P + 178147937.0D-8 * T**3
      P = P - 1821255978.0D-9 * T**4
      P = P + 1330274429.0D-9 * T**5
      ZPRB = Q * P
      GO TO 2
C
1     ZPRB = Q * ( DSQRT( 4.0D0 + X * X ) - X ) / 2.0D0
2     IF( Z .LT. 0.0D0 ) ZPRB = 1.0 - ZPRB
C
      RETURN
      END

```

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