COMPUTER TECHNOLOGY

Parametric interactions in EEG period analysis

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Off-line statistical analysis of computer-generated EEG period distribution parameters indicates the presence of important interactions within the traditional frequency bands and that confounded psychological variables null out highly significant results.

Period analysis has been unequivocally effective in EEG research (e.g., Creutzfeldt, Grunewald, Simonova, & Schmitz, 1969; Rouse, Peterson, & Shapiro, 1975; Sharp, Smith, & Surwillo, 1975; Surwillo, 1975). With respect to percent activity within the traditional EEG frequency bands, Beatty and Figueroa (1974) reported a .79 correlation between period and Fourier analysis results. They suggested that the simpler period-analytic methods be used to estimate frequency-band percent-time measures.

Notwithstanding certain theoretical restrictions, Fourier analysis continues to provide meaningful information about the EEG (Dumeruth & Keller, 1973). In contrast to most applications that use the power spectrum, Sayer (1974) showed that the auditory evoked potential is generated by a change in the cosine series (phase spectrum) with no discernible change in the power spectrum. To date, no one has solved the persistent problem of within-epoch phase shifts that degrade estimates of nonstationary components contributing to the power spectrum. Hoovey, Heinemann, and Creutzfeldt (1972) showed that phase shifts of the dominant occipital alpha rhythm occur frequently and both abruptly and gradually. When the Fourier series is used to represent nonrecurring functions (like the EEG is to a large extent), it is suggested that the analysis be done and remain valid only over the half-cycle interval between zero crossings (Richmond, 1972). In this case, only the sine or cosine series is computed, depending on the type of function. If this approach is taken, the second step or calculation of the fundamental is equivalent to half-wave period analysis.

Period analysis has normally been carried out with the assumption that spectral parameters (e.g., variance) are linearly related when computed on the basis of different data ranges (e.g., an 8- to 12-Hz bandpass compared to one of 9-11 Hz). This assumption does

not hold for the EEG. The analysis is further complicated by confounded psychological variables (e.g., arousal level and subjective affect) that alter the spectral interactions. The following example of this problem is based upon four consecutive 3-min cumulative period distributions taken from 24 human subjects, 12 male and 12 female (EEG $C_1 - A_2$, A_1 ground). Period analysis was based upon half-wave measurements of the full-wave rectified EEG (amplitude half down at 7 and 14 Hz) (Rouse, 1975). Spectral parameters computed on the basis of successively inclusive bandpass limits were compiled by a CDC 3150 computer according to the format shown in Table 1.

Table 1
Program Description

Constraints: The maximum number of trials for each subject is 10 and the maximum number of subjects is 999. The bandwidth is restricted to 8 Hz and must be in .5-Hz increments (this example uses the range 7-14 Hz).

Data preparation: Each data card for each subject must follow this pattern.

Column	Description
1-3	Three-digit subject number that must be right justified (i.e., 001, 002, 003, . . . , 010, 011, . . . , 999).
4-5	Two-digit card number that must also be right justified. This number is used along with the subject number to sort the data cards into proper order should the deck be dropped.
6	The code (1-9) for Condition A.
7	The code (1-9) for Condition B.
8	The code (1-9) for Condition C.
9-80	Raw data in the following order: Bin 1-Trial 1, Bin 2-Trial 1, Bin 2-Trial 2 . . . Bin 2-Trial N . . . Bin 15-Trial N. Use as many cards as necessary for each subject.

Parameter cards: Card I (all fields right justified)

Column	Description
1-5	The number of trials for this analysis.
6-10	Number of subjects.
11-15	The number of raw data cards per subject.
16-20	The number of variable format cards.
21-25	Any number punched in this field will cause the program to punch the results of all calculations into cards.

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Table 1 Continued

Column	Description
1-3	Frequency designation of the first bin.
4-6	Frequency designation of the second bin.
.	.
43-45	Frequency designation of the 15th bin.

All frequency bins are three digits in length and have an implied decimal point between the second and third digit (e.g., 07 0, 07 5, . . . , 13 5, 14 0).

Card III Variable format card(s).

Column	Description
1-80	This card describes the raw data to the program. All FORTRAN IV conventions apply. The card(s) must begin with a left parenthesis on the first card and end with a right parenthesis on the last card. Furthermore, it is mandatory that all variables be specified in floating point mode.

When describing the data to this program, the subject number and Codes A, B, and C will be specified as appearing on the first card (for the subject) only. The card numbers must always be ignored. For data with three cards per subject, four trials and 15 bins, the variable format for the first stage of analysis is: (F3.0, 2X, 3F1.0, 24F3.0/8X, 24F3.0/8X, 12F3.0)

Sample deck setup: \$JOB,; Binary program deck: \$RUN ; Card I ; Card II ; Card III ; Data Deck ; ~~33~~ End of File ; \$EOJ

Card output: All output cards will appear as follows:

Column	Description
1-3	Subject number.
4-5	Card number. This number will begin at 1 plus the number of input cards specified in Parameter Card I in Columns 11-15.
6-8	The codes for Conditions A, B, and C.
9-78	Up to 10 fields (7 columns/field) of data computed by this program. Each field represents the results from one trial.

The cards will be output in the following order: Summed counts in 7- to 14-Hz bins, 8- to 12-Hz bins, and 9- to 11-Hz bins; mean frequency (Hz) in ibid; standard deviation (Hz) ibid; skewedness (Hz) counts; kurtosis (Hz) ibid; ratios of 10-Hz counts/9- to 11-Hz counts, 10-Hz counts/8- to 12-Hz counts, 10-Hz counts/7- to 14-Hz counts, 9- to 11-Hz counts/8- to 12-Hz counts, 9- to 11-Hz counts/7- to 14-Hz counts, 8- to 12-Hz counts/7- to 14-Hz counts; differences of 9- to 11-Hz counts minus 10-Hz counts, 8- to 12-Hz counts minus 9- to 11-Hz counts, 7- to 14-Hz counts minus 8- to 12-Hz counts.

These calculations may be performed for any 8-Hz (or eight frequency class intervals) range in .5-Hz (or .5-interval) increments by changing parameter Card II and supplying the appropriate data. This example has used the range of 7-14 Hz. All changes will be proportional, however. If a range of 6-13 Hz is used, for example, the following occurs: All references to 7-14 Hz become 6-13 Hz; 8-12 Hz becomes 7-11 Hz; 9-11 Hz becomes 8-10 Hz, and 10 Hz becomes 9 Hz.

As a means of conserving space on the output cards, all fields requiring a decimal point have been multiplied by an appropriate scaler to eliminate the decimal. This method provides the user with the equivalent of an implied decimal, the position of which can be determined from the printed report.

For subsequent analysis on the output deck, the variable format (including the input data deck as front running cards segregated for each subject) is as follows:

(5X,3F1.0,24F3.0/8X,24F3.0/8X,12F3.0,3(/8X,4F7.0),12(/8X,4F7.2),6(8X,4F7.3),3(/8X,4F7.0))

Table 2 is an example of the data matrix printout for one subject. These distribution parameters are generated on the basis of four serial 3-min period spectra. The original bin counts are shown in Table 3. Results with this approach have been meaningful and unique in some cases. For example, during a meditation including EEG alpha biofeedback, subjects who report the absence of drowsiness show an increase in counts in the 7- to 14-Hz, 8- to 12-Hz, and 9- to 11-Hz ranges, while subjects who report drowsiness show significant increases in the 7- to 14-Hz and 9- to 11-Hz ranges only after feedback is terminated and a continuous decrease in the 8- to 12-Hz range during and after feedback. Spectral dynamics indicate that nondrowsing subjects show markedly better midrange entrainment (9-11 Hz), while not differing from the drowsing subjects in terms of mean frequency, which uniformly decreases for all subjects. Drowers also show a marked transfer of counts from the 12-Hz to the 7.5-Hz bin. Drower variance differs (is greater) from the nondrowers only when computed on the basis of the 7- to 14-Hz and 8- to 12-Hz count ranges. Nondrowers show an exclusive decrease in variance and kurtosis parameters computed for the 8- to 12-Hz range, an exclusive increase in 10-Hz counts,

Table 2

	Time Block			
	1	2	3	4
Summed Counts in				
10 Hz Bin	464	705	739	718
7-14 Hz Bins	3,335	3,694	3,440	3,447
8-12 Hz Bins	2,792	3,298	3,144	3,143
9-11 Hz Bins	1,953	2,575	2,563	2,572
Mean Frequency in				
7-14 Hz Bins	10.59	10.21	10.14	10.12
8-12 Hz Bins	10.23	10.07	10.02	9.97
9-11 Hz Bins	10.13	10.01	9.98	9.96
Standard Deviation in				
7-14 Hz Bins	1.48	1.40	1.26	1.26
8-12 Hz Bins	1.08	1.06	.98	.97
9-11 Hz Bins	.65	.73	.70	.71
Skewedness in				
7-14 Hz Bins	.83	.98	.98	1.02
8-12 Hz Bins	-.66	-.12	.40	.41
9-11 Hz Bins	-.39	-.23	.25	.28
Kurtosis in				
7-14 Hz Bins	1.88	1.84	1.75	1.74
8-12 Hz Bins	1.33	1.28	1.22	1.21
9-11 Hz Bins	.76	.81	.79	.79
Count Ratios				
10 Hz to 9-11 Hz	.238	.274	.288	.279
10 Hz to 8-12 Hz	.166	.214	.235	.228
10 Hz to 7-14 Hz	.129	.191	.215	.208
9-11 Hz to 8-12 Hz	.699	.781	.815	.818
9-11 Hz to 7-14 Hz	.586	.697	.745	.746
8-12 Hz to 7-14 Hz	.837	.893	.914	.912
Count Differences				
9-11 Hz minus 10 Hz	1,489	1,870	1,824	1,854
8-12 Hz minus 9-11 Hz	839	723	581	571
7-14 Hz minus 8-12 Hz	543	396	296	304

Table 3
Original Bin Counts

	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0130121	009	031	032	023	055	087	052	050	129	111	095	107	174	193	164	172	224	370	351	385	369	539	602	612
0130221	464	705	739	718	482	579	537	548	424	382	334	309	294	254	196	183	242	165	126	109	172	099	085	103
0130321	140	084	058	055	103	053	029	041	064	042	040	032												

Note—The first entry in each line indicates the three-digit subject number (Digits 1-3), the two-digit card number (Digits 4-5), and the code for Condition A, B, or C (Digits 6-7). The remaining entries indicate the bin counts for frequency class intervals increasing in .5-Hz increments (i.e., starting with Line 1, Columns 1-4 refer to 7.0 Hz, Columns 5-8 refer to 7.5 Hz, continuing in left-to-right order to Line 3, Columns 9-12, which refer to 14.0 Hz).

more 9.5- and 10-Hz counts, and less 12- to 14-Hz counts, both within their own distributions over time and when compared to the drowsers. *A statistical analysis that confounds data from the drowsers and nondrowsers shows no significant change in variance within any of the three ranges used here.* It is not unreasonable to expect that other range calculations might produce additional information. Analysis of the intercorrelation matrix patterns indicated that the nondrowsers show a very general and markedly high degree of covariance, while drowsers are very poor in this respect ($p < .001$).

It is important to note that these differences are a function of the experimental setting. The psychological dimension of affect was orthogonal to arousal on every

measure except kurtosis, which was the only parameter to differentiate positive from negative affect when computed on the basis of the 8- to 12-Hz range (there was a trend for a difference occurring for the variance measure for this same range). Subjects who report a preference for the feedback tone produce more peaked distributions; that is, they are leptokurtotic (a lower kurtosis index). These and other results confirm the hypothesis that arousal level and affective state can both influence the EEG but in different ways. The results also suggest that a single parameter analysis of EEG (e.g., percent time alpha) is highly limited, and that confounded psychological variables can obscure important results. A complete program listing is given in the Appendix.

APPENDIX

MS FORTRAN (4.3) / MSOS 5.0

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PROGRAM EEG PERIOD ANALYSIS

```

REAL K714,K812,K911,ISUBJ,ICOND,ICRD
DIMENSION BINS(15),DATA(15,10),C714(10),C812(10),C911(10)
DIMENSION XBAR714(10),XBAR812(10),XBAR911(10),SD714(10),SD812(10)
DIMENSION SD911(10),SK714(10),SK812(10),SK911(10),K714(10)
DIMENSION K812(10),K911(10),R10911(10),R10812(10),R10714(10)
DIMENSION R9812(10),R9714(10),R8714(10),C9C10(10),C8C9(10)
DIMENSION C7C8(10),ICOND(3),IFORMI(200)

```

C

FORMAT SECTION

C

C

INPUT FORMATS

C

```

100 FORMAT(5I5)
110 FORMAT(15F3.1)
120 FORMAT(20A4)

```

C

C

OUTPUT FORMATS

C

```

200 FORMAT(1H1,52X, #BIOMUSIC LABORATORY EXPERIMENT#,43X, #PAGE#,I4/14 ,
-57X, #REPORTED BY SUBJECT#)
210 FORMAT(1H-,31X, #SUBJECT NUMBER#,F4,3X, #CONDITION A =#,F2,3X,
-#CONDITION B =#,F2,3X, #CONDITION C =#,F2)
215 FORMAT(1H0)
220 FORMAT(1H , #SUMMED COUNTS IN#,F5.1,2H -,F5.1, # HZ. BINS#,16X,
-10F8)
230 FORMAT(1H , #MEAN FREQUENCY IN#,F5.1,2H -,F5.1, # HZ. BINS#,15X,
-10F8.2)
240 FORMAT(1H , #STANDARD DEVIATION IN#,F5.1,2H -,F5.1, # HZ. BINS#,11X,
-10F8.2)
250 FORMAT(1H , #SKEWEDNESS IN#,F5.1,2H -,F5.1, # HZ. BINS#,19X,10F8.2)
260 FORMAT(1H , #KURTOSIS IN#,F5.1,2H -,F5.1, # HZ. BINS#,21X,10F8.2)

```

```

270 FORMAT(1H ,F4.1,2H -,F5.1,*,HZ. TO*,F5.1,2H -,F5.1,*,HZ. COUNT *,
      -*,RATIO*,7X,10F8.3)
280 FORMAT(1H ,F4.1,2H -,F5.1,*,HZ. MINUS*,F5.1,2H -,F5.1,
      -*,HZ. COUNTS*,9X,10F8)
295 FORMAT(F3,F2,3F1,10F7)

```

C
C
C

CONSTANT SECTION

IPAGE = 0

C
C
C

INPUT THE DATA AND PARAMETER CARDS

```

READ(60,100) NBLOCK,NSUBJ,NCARD,IFORM1,IPUN
READ(60,110) (BINS(I),I=1,15)
IF(IFORM1 .LE. 0) IFORM1 = 1
IFORM1 = IFORM1*20
READ(60,120) (IFORM1(I),I=1,IFORM1)

```

C
C
C

```

300 READ(60,IFORM1)ISUBJ,(ICOND(I),I=1,3),
      -((DATA(I,J),J=1,NBLOCK),I=1,15)

```

C

ICRD = NCARD

C
C
C

COUNT FREQUENCY SETS FOR EACH TIME BLOCK

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```

DO 340 J = 1,NBLOCK
C714(J) = 0.
C812(J) = 0.
C911(J) = 0.
DO 310 I = 1,15
C714(J) = C714(J)+DATA(I,J)
310 CONTINUE
DO 320 I = 3,11
C812(J) = C812(J)+DATA(I,J)
320 CONTINUE
DO 330 I = 5,9
C911(J) = C911(J)+DATA(I,J)
330 CONTINUE
340 CONTINUE

```

C
C
C

MEAN FREQUENCY FOR EACH TIME BLOCK

```

DO 380 J = 1,NBLOCK
TEMP = 0.
DO 350 I = 1,15
TEMP = TEMP+(BINS(I)*DATA(I,J))
350 CONTINUE
XBAR714(J) = TEMP/C714(J)
TEMP = 0.
DO 360 I = 3,11
TEMP = TEMP+(BINS(I)*DATA(I,J))
360 CONTINUE
XBAR812(J) = TEMP/C812(J)
TEMP = 0.
DO 370 I = 5,9
TEMP = TEMP+(BINS(I)*DATA(I,J))
370 CONTINUE
XBAR911(J) = TEMP/C911(J)
380 CONTINUE

```

C
C
C

STANDARD DEVIATION FOR EACH TIME BLOCK

```

      DO 420 J = 1,NBLOCK
      TEMP = 0.
      DO 390 I = 1,15
      TEMP = TEMP+(DATA(I,J)*(BINS(I)-XBAR714(J))**2)
390  CONTINUE
      SD714(J) = (TEMP/C714)**.5
      TEMP = 0.
      DO 400 I = 3,11
      TEMP = TEMP+(DATA(I,J)*(BINS(I)-XBAR812(J))**2)
400  CONTINUE
      SD812(J) = (TEMP/C812)**.5
      TEMP = 0.
      DO 410 I = 5,9
      TEMP = TEMP+(DATA(I,J)*(BINS(I)-XBAR911(J))**2)
410  CONTINUE
      SD911(J) = (TEMP/C911)**.5
420  CONTINUE
C
C          SKEWEDNESS FOR EACH TIME BLOCK
C
      DO 460 J = 1,NBLOCK
      TEMP = 0.

```

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```

      DO 430 I = 1,15
      TEMP = TEMP+(DATA(I,J)*(BINS(I)-XBAR714(J))**3)
430  CONTINUE
      SK714(J) = (ABS(TEMP)/C714)**.33
      IF(TEMP .LT. 0) SK714(J) = SK714(J)*(-1.)
      TEMP = 0.
      DO 440 I = 3,11
      TEMP = TEMP+(DATA(I,J)*(BINS(I)-XBAR812(J))**3)
440  CONTINUE
      SK812(J) = (ABS(TEMP)/C812)**.33
      IF(TEMP .LT. 0) SK812(J) = SK812(J)*(-1.)
      TEMP = 0.
      DO 450 I = 5,9
      TEMP = TEMP+(DATA(I,J)*(BINS(I)-XBAR911(J))**3)
450  CONTINUE
      SK911(J) = (ABS(TEMP)/C911)**.33
      IF(TEMP .LT. 0) SK911(J) = SK911(J)*(-1.)
460  CONTINUE

```

```

C
C          KURTOSIS FOR EACH TIME BLOCK
C

```

```

      DO 500 J = 1,NBLOCK
      TEMP = 0.
      DO 470 I = 1,15
      TEMP = TEMP+(DATA(I,J)*(BINS(I)-XBAR714(J))**4)
470  CONTINUE
      K714(J) = (TEMP/C714)**.25
      TEMP = 0.
      DO 480 I = 3,11
      TEMP = TEMP+(DATA(I,J)*(BINS(I)-XBAR812(J))**4)
480  CONTINUE
      K812(J) = (TEMP/C812)**.25
      TEMP = 0.
      DO 490 I = 5,9
      TEMP = TEMP+(DATA(I,J)*(BINS(I)-XBAR911(J))**4)
490  CONTINUE
      K911(J) = (TEMP/C911)**.25
500  CONTINUE

```

C

C RATIOS FOR EACH TIME BLOCK

C

```
DO 510 J = 1,NBLOCK
R10911(J) = DATA(7,J)/C911(J)
R10812(J) = DATA(7,J)/C812(J)
R10714(J) = DATA(7,J)/C714(J)
R9812(J) = C911(J)/C812(J)
R9714(J) = C911(J)/C714(J)
R8714(J) = C812(J)/C714(J)
```

510 CONTINUE

C

C

C

DIFERENCES IN COUNTS FOR EACH TIME BLOCK

```
DO 520 J = 1,NBLOCK
C9C10(J) = C911(J)-DATA(7,J)
C8C9(J) = C812(J)-C911(J)
C7C8(J) = C714(J)-C812(J)
```

520 CONTINUE

C

C

OUTPUT TO PRINTER

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C

```
IPAGE = IPAGE+1
WRITE(61,200) IPAGE
WRITE(61,210) ISUBJ, (ICOND(I), I=1,3)
WRITE(61,215)
WRITE(61,220) BINS(1),BINS(15), (C714(I), I=1,NBLOCK)
WRITE(61,220) BINS(3),BINS(11), (C812(I), I=1,NBLOCK)
WRITE(61,220) BINS(5),BINS(9), (C911(I), I=1,NBLOCK)
WRITE(61,220) BINS(7),BINS(7), (DATA(7,I), I=1,NBLOCK)
WRITE(61,215)
WRITE(61,230) BINS(1),BINS(15), (XBAR714(I), I=1,NBLOCK)
WRITE(61,230) BINS(3),BINS(11), (XBAR812(I), I=1,NBLOCK)
WRITE(61,230) BINS(5),BINS(9), (XBAR911(I), I=1,NBLOCK)
WRITE(61,215)
WRITE(61,240) BINS(1),BINS(15), (SD714(I), I=1,NBLOCK)
WRITE(61,240) BINS(3),BINS(11), (SD812(I), I=1,NBLOCK)
WRITE(61,240) BINS(5),BINS(9), (SD911(I), I=1,NBLOCK)
WRITE(61,215)
WRITE(61,250) BINS(1),BINS(15), (SK714(I), I=1,NBLOCK)
WRITE(61,250) BINS(3),BINS(11), (SK812(I), I=1,NBLOCK)
WRITE(61,250) BINS(5),BINS(9), (SK911(I), I=1,NBLOCK)
WRITE(61,215)
WRITE(61,260) BINS(1),BINS(15), (K714(I), I=1,NBLOCK)
WRITE(61,260) BINS(3),BINS(11), (K812(I), I=1,NBLOCK)
WRITE(61,260) BINS(5),BINS(9), (K911(I), I=1,NBLOCK)
WRITE(61,215)
WRITE(61,270) BINS(7),BINS(7),BINS(5),BINS(9),
-(R10911(I), I=1,NBLOCK)
WRITE(61,270) BINS(7),BINS(7),BINS(3),BINS(11),
-(R10812(I), I=1,NBLOCK)
WRITE(61,270) BINS(7),BINS(7),BINS(1),BINS(15),
-(R10714(I), I=1,NBLOCK)
WRITE(61,270) BINS(5),BINS(9),BINS(3),BINS(11),
-(R9812(I), I=1,NBLOCK)
WRITE(61,270) BINS(5),BINS(9),BINS(1),BINS(15),
-(R9714(I), I=1,NBLOCK)
WRITE(61,270) BINS(3),BINS(11),BINS(1),BINS(15),
-(R8714(I), I=1,NBLOCK)
WRITE(61,215)
WRITE(61,280) BINS(5),BINS(9),BINS(7),BINS(7),
-(C9C10(I), I=1,NBLOCK)
WRITE(61,280) BINS(3),BINS(11),BINS(5),BINS(9),
-(C8C9(I), I=1,NBLOCK)
```

```

      WRITE(61,280) BINS(1),BINS(15),BINS(3),BINS(11),
      -(C7C8(I),I=1,NBLOCK)

```

C
C
C
C
C

```

      OUTPUT TO CARDS

```

```

      IF PROCESSING OF RAW DATA BY ANOTHER PROGRAM IS
      DESIRED, THE INPUT FROM THIS PROGRAM SHOULD BE USED.

```

```

      IF(IPUN.EQ.0) GO TO 600
      DO 530 J = 1,NBLOCK
      XBAR714(J) = XBAR714(J)*100
      XBAR812(J) = XBAR812(J)*100
      XBAR911(J) = XBAR911(J)*100
      SD714(J) = SD714(J)*100
      SD812(J) = SD812(J)*100
      SD911(J) = SD911(J)*100

```

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```

      SK714(J) = SK714(J)*100
      SK812(J) = SK812(J)*100
      SK911(J) = SK911(J)*100
      K714(J) = K714(J)*100
      K812(J) = K812(J)*100
      K911(J) = K911(J)*100
      R10911(J) = R10911(J)*1000
      R10812(J) = R10812(J)*1000
      R10714(J) = R10714(J)*1000
      R9812(J) = R9812(J)*1000
      R9714(J) = R9714(J)*1000
      R8714(J) = R8714(J)*1000

```

530 CONTINUE

```

      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(C714(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(C812(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(C911(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(XBAR714(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(XBAR812(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(XBAR911(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(SD714(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(SD812(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(SD911(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(SK714(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(SK812(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(SK911(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(K714(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(K812(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(K911(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(R10911(J),J=1,NBLOCK)
      ICRD = ICRD+1
      WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(R10812(J),J=1,NBLOCK)
      ICRD = ICRD+1

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WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(R10714(J),J=1,NBLOCK)
ICRD = ICRD+1
WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(R9812(J),J=1,NBLOCK)
ICRD = ICRD+1
WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(R9714(J),J=1,NBLOCK)
ICRD = ICRD+1
WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(R8714(J),J=1,NBLOCK)
ICRD = ICRD+1
WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(C9C10(J),J=1,NBLOCK)
ICRD = ICRD+1
WRITE(62,295) ISUBJ,ICPD,(ICOND(I),I=1,3),(C8C9(J),J=1,NBLOCK)
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ICRD = ICRD+1
WRITE(62,295) ISUBJ,ICRD,(ICOND(I),I=1,3),(C7C8(J),J=1,NBLOCK)
600 IF(ISUBJ .GE. NSUBJ) STOP
GO TO 300
END

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REFERENCES

- BEATTY, J., & FIGUEROA, C. Period analytic algorithms for the estimation of selected spectral properties of short segments of EEG data. *Behavior Research Methods & Instrumentation*, 1974, 6, 293-295.
- CREUTZFELDT, GRUNEWALD, G., SIMONOVA, O., & SCHMITZ, H. Changes of the basic rhythms of the EEG during the performance of mental and visuomotor tasks. In C. R. Evans & T. B. Mulholland (Eds.), *Attention in neurophysiology*. London: Butterworth, 1969. Pp. 148-168.
- DUMERMUTH, G., & KELLER, E. EEG spectral analysis by means of fast fourier transform. In P. Kellaway & I. Petersen (Eds.), *Automation of clinical electroencephalography*. New York: Raven Press, 1973. Pp. 145-159.
- HOOVEY, Z. B., HEINEMANN, U., & CREUTZFELDT, O. D. Inter-hemispheric "synchrony" of alpha waves. *EEG Journal*, 1972, 32, 337-347.
- RICHMOND, A. E. *Calculus for electronics*. New York: McGraw-Hill, 1972. P. 413.
- ROUSE, L. O. On-line period analysis of EEG by time-to-amplitude conversion (TAC). *Psychophysiology*, 1975, 12, 476-479.
- ROUSE, L. O., PETERSON, J., & SHAPIRO, G. EEG alpha entrainment reaction within the biofeedback setting and some possible effects on epilepsy. *Physiological Psychology*, 1975, 3, 113-122.
- SAYER, G. The mechanism of auditory evoked EEG responses. *Nature*, 1974, 247, 481-483.
- SHARP, F. H., SMITH, G. W., & SURWILLO, W. W. Period analysis of the electroencephalogram with recording of interval histograms of EEG half-wave durations. *Psychophysiology*, 1975, 12, 471-475.
- SURWILLO, W. W. Interval histogram analysis of period of the electroencephalogram in relation to age during growth and development in normal children. *Psychophysiology*, 1975, 12, 506-512.

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