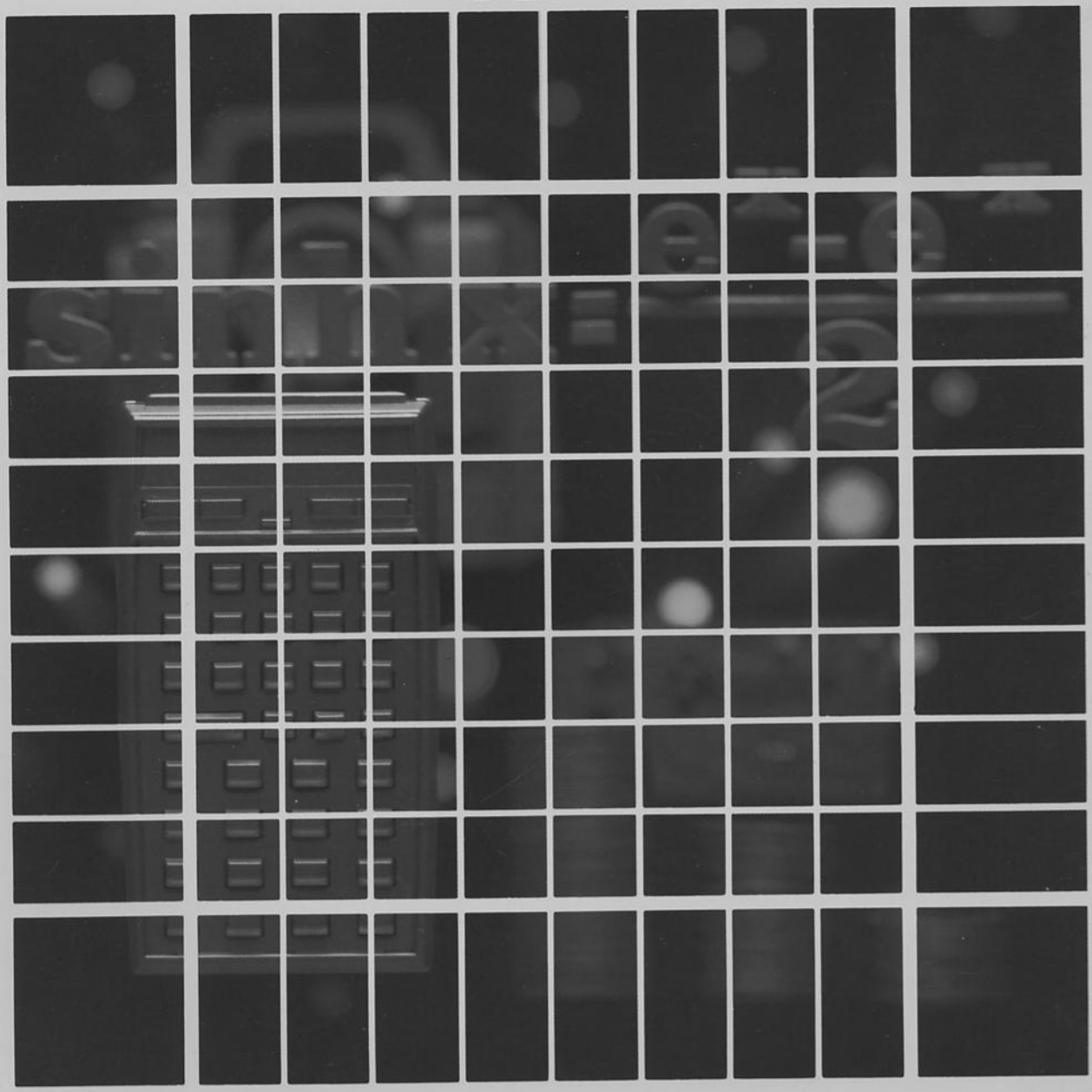
HEWLETT-PACKARD

HP-41C

USER'S
LIBRARY SOLUTIONS

Applied statistics I



- Chi-square distribution

a - n' odd

$$P(\chi^2,n') = 2\,P(\chi) + 2\,Z(\chi) \sum_{r=1}^{(n'-1)/2} \frac{\chi^{2r-1}}{1.5.5....(2r-1)}$$

b - n' even

$$P(\chi^2,n') = \sqrt{2\pi}\,Z(\chi) \left[1 + \sum_{r=1}^{(n'-2)/2} \frac{\chi^{2r}}{2.4.6....2r}\right.$$

$\chi = \sqrt{\chi^2}$ $Z(\chi)$ and $P(\chi)$ from the normal distribution

- F distribution

n'_1 = d.f.of the numerator n'_2 = d.f.of the denominator of F

$P(F,n'_1,n'_2)$ is computed like P(u), with the transformation :

$$u = \frac{(1 - 2/9\ n'_2)\ F^{1/3} - (1 - 2/9\ n'_1)}{\sqrt{\frac{2}{9\ n'_1} + \frac{2}{9\ n'_2} F^{2/3}}}$$

From : M.ABRAMOWITZ & I.STEGUN - Handbook of Mathematical Functions.

The exemples in the programs come from :

J.PHILIPPE - Les Méthodes statistiques en Pharmacie et en Chimie
Masson Paris 1967

S.SIEGEL - Non Parametric statistics Mc Graw Hill New York 1975

G.W.SNEDECOR & W.G.COCHRAN - Méthodes statistiques A.C.T.A. Paris 1971

USER'S GENERAL INSTRUCTIONS

All the programs are for HP 41 C with the card reader and the printer attached, and one or two memory modules.

In the instructions, the quote mark "....." around a group of characters indicates that this group is ALPHA. The key ALPHA must be pressed before and after entering the instruction.

- the user mode should be always on
- the statistical registers are located in R14 to R19
- all the data are entered through the R/S key
- a correction subroutine is provided to correct a wrong data, initialized by E.
- the yellow prefix key ◻ is denoted in the instructions by p. (for instance, p.A = a)

Before keying in a new program :

- clear the previous one by : XEQ ALPHA CLP ALPHA ; ALPHA ALPHA
- be sure that all the flags of a previous program are cleared
- set the proper number of data storage registers by XEQ "SIZE" —— (the size allocation required for each program is indicated in the status information sheet)

Before executing a new program, it is initialized by : XEQ "name"; this initialization is not necessary for other runs with the same program and other sets of data.

The number of decimals is usually set at 2; if more are needed, according to the nature of the data, they can be set by p.FIX -

STAT.01 -

MEAN AND CONFIDENCE INTERVAL

DESCRIPTION -

From a sample of n observations, the mean is calculated :

$$\bar{y} = \frac{1}{n} \sum y_i$$

This sample is considered as drawn at random from a normal population with mean μ and standard deviation σ. From the central-limit theorem, it is known that the distribution of the mean of samples of size n from this population is also normal, with mean μ and standard error $\sigma / \sqrt{n}$. The confidence interval of the mean is :

$$\bar{y} - u_p \sigma / \sqrt{n} \leqslant \mu \leqslant \bar{y} + u_p \sigma / \sqrt{n}$$

For $u_p = u_{0,05} = 1,96$, the confidence interval calculated will include 19 times out of 20, on the long run, the true mean μ. These limits are the 95 % confidence limits.

Generally, the true value of σ is not known and must be estimated from the data, with :

$$s = \sqrt{\frac{\sum y^2 - (\sum y)^2/n}{(n-1)}}$$

In this case, the distribution of "t" is used instead of the normal distribution, and the confidence interval is :

$$\bar{y} - t_p s / \sqrt{n} \leqslant \mu \leqslant \bar{y} + t_p s / \sqrt{n}$$

t_p is the value of t for the number of degrees of freedom (n - 1) and the chosen probability p.

This program computes the mean and the 95 % and 99 % confidence limits, with σ known, or estimated by s.

USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

STAT.01

Step / Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.01, tracks 1 and 2.			
2	Initialize		XEQ"INT.CONF."	
3	Standard deviation σ known			
	Call		C	
	Input	σ	R/S	
3'	Standard deviation s estimated			
	Call		A	
4	Input the data y_i	y_i	R/S	
5	Correction routine			
	Call		E	
	Input the erroneous y	y_E	R/S	
	Input the correct y	y_C	R/S	
6	After the last y_i			
	Call		B	
	Display of : mean			MOY. $\bar{y}$
	standard deviation			D.S. σ or s
	standard error			E.S. $s_{\bar{y}}$
	Confidence interval			
	P = 0,95			
	Lower limit			L.I.
	Upper limit			L.S.
	P = 0,99			
	Lower limit			L.I.
	Upper limit			L.S.
7	For another set of data, go to step 3 or 3'			

EXAMPLE 1 - σ known. (*)

A sample of 10 data : 34,30 - 34,60 - 34,00 - 34,85 - 33,60 -
34,20 - 34,10 - 33,80 - 34,10 - 36,45 -
is drawn at random from a population with a standard deviation $\sigma = 0,75$

```
XEQ "INTCONF"
      XEQ C
  0.75   RUN

 34.30   RUN
 34.60   RUN
 34.00   RUN
 34.85   RUN
 33.60   RUN
 34.20   RUN
 34.10   RUN
 33.80   RUN
 34.10   RUN
 36.45   RUN
      XEQ B
```

```
MOY.=34.40
D.S.=0.75
E.S.=0.24
D.L.=9.00

P=0,95
L.I.=33.94
L.S.=34.86

P=0,99
L.I.=33.79
L.S.=35.01
```

EXAMPLE 2 - s estimated

Same data

```
          XEQ "INTCONF"
                XEQ A
           34.30   RUN
           34.60   RUN
           34.00   RUN
           34.85   RUN
(error)   336.00   RUN
                XEQ E
          336.00   RUN
           33.60   RUN
           34.20   RUN
           34.10   RUN
           33.80   RUN
           34.10   RUN
           36.45   RUN
                XEQ B
```

```
MOY.=34.40
D.S.=0.81
E.S.=0.25
D.L.=9.00

P=0,95
L.I.=33.82
L.S.=34.98

P=0,99
L.I.=33.57
L.S.=35.23
```

(*) PHILIPPE. pp.26 and 33.

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

Line Zeile Ligne Linea	Keystrokes Tastenfolge Touches Tasti	Comments Kommentar Commentaires Commenti	Line Zeile Ligne Linea	Key pressed Tastenfolge Touches Tasti	Comments Kommentar Commentaires Commenti
01					
	01♦LBL "INTCONF"			51 RCL 03	
	02 CLRG			52 /	
	03 CF 00			53 E↑X	
	04 RTN			54 1.576	
	05♦LBL C			55 +	
	06 STOP			56 FS? 00	
	07 STO 00			57 2.576	
	08 ADV			58 "P=0,99"	
	09 SF 00			59 AVIEW	
	10♦LBL A			60 XEQ 02	
	11♦LBL 01			61 RTN	
	12 STOP			62♦LBL 02	
	13 EREG 14			63 RCL 02	
	14 Σ+			64 *	
	15 GTO 01			65 STO 04	
	16♦LBL B			66 RCL 01	
	17 MEAN			67 -	
	18 "MOY."			68 CHS	
	19 XEQ 11			69 "L.I."	
	20 STO 01			70 XEQ 11	
	21 SDEV			71 LASTX	
	22 FS? 00			72 RCL 04	
	23 RCL 00			73 +	
	24 "D.S."			74 "L.S."	
	25 XEQ 11			75 XEQ 11	
	26 RCL 19			76 ADV	
	27 SQRT			77 RTN	
	28 /			78♦LBL 11	
	29 STO 02			79 "⊢="	
	30 "E.S."			80 ARCL X	
	31 XEQ 11			81 AVIEW	
	32 RCL 19			82 RTN	
	33 1			83♦LBL E	
	34 -			84 STOP	
	35 STO 03			85 Σ-	
	36 "D.L."			86 GTO 01	
	37 XEQ 11			87 .END.	
	38 ADV				
	39 2.3777				
	40 RCL 03				
	41 /				
	42 E↑X				
	43 .96				
	44 +				
	45 FS? 00				
	46 1.96				
	47 "P=0,95"				
	48 AVIEW				
	49 XEQ 02				
	50 4.65				
50					

STAT.01

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers
Datenspeicher
Registres de données
Registri

00	σ	50	
01	$\bar{y}$		
02	$s_{\bar{y}}$		
03	d.f.		
04	t $s_{\bar{y}}$		
05		55	
10		60	
15		65	
20		70	
25		75	
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 026 Total Reg. _____

User Mode

Eng	☐	Fix	☑	Sci	☐	On ☒
Deg	☐	Rad	☐	Grad	☐	Off ☐

Purpose
Bedeutung
Signification
Scopo

Flags

		SET	CLEAR	
00		X		
01				
02				
03				
04				
05				
06				
07				
08				
09				
10				
11	Audio execute			
12				
13				
14				
15				
16				
17				
18				
19				
20				
21	Printer Enable			
22	Number Input			
23	Alpha Input			
24	Range Ignore			
25	Error Ignore			
26	Audio Enable			
27	User Mode			
28	Decimal Point			
29	Digit Grouping			

Assignments
Tastenbelegung/Assignations/Assegnamenti

Function Funktion Fonction Funzione	Key Taste Touche Tasto	Function Funktion Fonction Funzione	Key Taste Touche Tasto

STAT.02 -

ONE SAMPLE

HISTOGRAM - NORMALITY TESTS

DESCRIPTION -

When a sample is large enough ($n > 30$), it is possible to build a table of frequency distributions, from which a frequency histogram can be constructed. This histogram will give an idea of the shape of the distribution of the parent population. The number of cells of this table is chosen by the user, who selects the lower limit of the first cell y_0 and the celle size L.

If the data are not already grouped, they are input one after the other and classified by the program in the several cells. The program computes :

- the mean : $\bar{y} = \sum y_i / N$
- the standard deviation : $s = \sqrt{\dfrac{\sum y^2 - (\sum y)^2/N}{N-1}}$

The normality of the distribution may be checked by computing g_1 and g_2, estimations of γ_1, coefficient of symmetry (or skewness) and γ_2, coefficient of kurtosis. These coefficients are computed from the moments of order 3 and 4, as :

$$g_1 = 1 / ns^3 \sum (y_i - \bar{y})^3$$

$$g_2 = 3 - (1 / ns^4) \sum (y_i - \bar{y})^4$$

They are both zero when the population is normal. A negative g_1 indicates skewness to the left; a positive g_1 skewness to the right. A negative g_2 indicate platykurtosis; a positive g_2 shows leptokurtosis.

The y_i may be replaced by their logarithms to see if the distribution is log.normal.

If the data are already grouped in a frequency distribution, they are input directly. In both cases, the program prints :

- the midpoint of each class
- the frequency in this class f_i
- the relative frequency $f_i\,\% = \dfrac{100\, f_i}{N}$
- the cumulative relative frequencies $\sum f_i\%$

From these data, one can check the normality by a graphical method using probability paper.

STAT.02

USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.02, tracks 1 to 4			
2	Initialize		XEQ "HIST."	
3	a- Transform of y to log.y Call		C	
3'	b- Ungrouped data Call		A	
4	Input : lower limit of first cell	y_0	R/S	
	cell size	L	R/S	
5	Input the data	y_i	R/S	
6	Correction routine Call		E	
	Input the erroneous y	y_E	R/S	
	Input the correct y	y_C	R/S	
7	Call		D	
	Display of : sample size			N
	mean			MOY.
	standard deviation			D.S.
	coeff. skewness			g_1
	coeff. kurtosis			g_2
	Frequency distribution :			
	class midpoint			y'
	frequency			f
	relative frequency			f %
	cumulative relat. freq.			Σ f %
8	c- Grouped data Call		B	
9	Input : sample size	N	R/S	
10	For each class, input :			
	class midpoint	y'	R/S	
	frequency	f	R/S	
11	Correction routine If y' is erroneous, enter f before calling	E		
	Input again the erroneous pair	y'_E	R/S	
		f_E	R/S	
	then the correct data		D	
12	Call			
	Display of : sample size			N
	mean			MOY.
	standard deviation			D.S.
	coeff.skewness			g_1
	coeff.kurtosis			g_2
13	For another set of data, go to step 2.			

EXAMPLE 1 - Ungrouped data

```
   XEQ "HIST"          N=40.000
       XEQ A           MOY.=11.475
10.025   RUN           D.S.=0.689
 0.350   RUN           g1=0.319
                       g2=0.103
12.200   RUN
10.700   RUN                      10.200    ***
12.100   RUN           f=1.000
10.800   RUN           f%=2.500
12.900   RUN           Σf%=2.500
11.500   RUN
11.900   RUN                      10.550    ***
11.600   RUN           f=6.000
11.800   RUN           f%=15.000
11.300   RUN           Σf%=17.500
10.400   RUN
10.400   RUN                      10.900    ***
11.200   RUN           f=4.000
10.700   RUN           f%=10.000
10.700   RUN           Σf%=27.500
11.700   RUN
11.600   RUN                      11.250    ***
11.600   RUN           f=7.000
10.800   RUN           f%=17.500
12.000   RUN           Σf%=45.000
11.100   RUN
11.900   RUN                      11.600    ***
11.000   RUN           f=7.000
12.400   RUN           f%=17.500
12.300   RUN           Σf%=62.500
13.300   RUN
11.900   RUN                      11.950    ***
11.700   RUN           f=9.000
12.200   RUN           f%=22.500
11.200   RUN           Σf%=85.000
10.200   RUN
11.800   RUN                      12.300    ***
11.800   RUN           f=4.000
10.500   RUN           f%=10.000
10.900   RUN           Σf%=95.000
11.300   RUN
11.800   RUN                      12.650    ***
11.100   RUN           f=0.000
11.600   RUN           f%=0.000
11.100   RUN           Σf%=95.000
       XEQ D
                                  13.000    ***
                      f=1.000
                      f%=2.500
                      Σf%=97.500

                                  13.350    ***
                      f=1.000
                      f%=2.500
                      Σf%=100.000
```

EXAMPLE 2 - Ungrouped data Log. transform

```
   XEQ "HIST"          N=40.000
       XEQ C           MOY.=1.059
       XEQ A           D.S.=0.026
 1.006   RUN           g1=0.138
  .012   RUN           g2=-0.178
12.200   RUN                       1.012    ***
10.700   RUN
15.100   RUN           f=3.000
       XEQ E           f%=7.500
15.100   RUN           Σf%=7.500
12.100   RUN                       1.024    ***
10.800   RUN
12.900   RUN           f=4.000
11.500   RUN           f%=10.000
11.900   RUN           Σf%=17.500
11.600   RUN                       1.036    ***
11.800   RUN
11.300   RUN           f=4.000
10.400   RUN           f%=10.000
10.400   RUN           Σf%=27.500
11.200   RUN                       1.048    ***
10.700   RUN
10.700   RUN           f=7.000
11.900   RUN           f%=17.500
11.600   RUN           Σf%=45.000
11.600   RUN                       1.060    ***
10.800   RUN
12.000   RUN           f=5.000
11.100   RUN           f%=12.500
11.900   RUN           Σf%=57.500
11.000   RUN                       1.072    ***
12.400   RUN
12.300   RUN           f=9.000
13.300   RUN           f%=22.500
11.900   RUN           Σf%=80.000
11.700   RUN                       1.084    ***
12.200   RUN
11.200   RUN           f=5.000
10.200   RUN           f%=12.500
11.800   RUN           Σf%=92.500
11.800   RUN                       1.096    ***
10.500   RUN
10.900   RUN           f=1.000
11.300   RUN           f%=2.500
11.800   RUN           Σf%=95.000
11.100   RUN                       1.108    ***
11.600   RUN
11.100   RUN           f=1.000
       XEQ D           f%=2.500
                       Σf%=97.500
                                  1.120    ***
                      f=1.000
                      f%=2.500
                      Σf%=100.000
```

NOTICE

The program material contained herein is supplied without representation or warranty of any kind. Hewlett-Packard Company therefore assumes no responsibility and shall have no liability, consequential or otherwise, of any kind arising from the use of this program material or any part thereof.

EXAMPLE 3 - Grouped data (*)

```
        XEQ "HIST"
            XEQ B
250,000     RUN

116,000     RUN
  1,000     RUN
  0,400     ***
  0,400     ***

117,000     RUN
  2,000     RUN
  0,800     ***
  1,200     ***

118,000     RUN
  2,000     RUN
  0,800     ***
  2,000     ***

119,000     RUN
  5,000     RUN
  2,000     ***
  4,000     ***

120,000     RUN
 10,000     RUN
  4,000     ***
  8,000     ***

(error)
131,000     RUN
 11,000     RUN
  4,400     ***
 12,400     ***

            XEQ E
131,000     RUN
 11,000     RUN
121,000     RUN
 11,000     RUN
  4,400     ***
 12,400     ***

122,000     RUN
 15,000     RUN
  6,000     ***
 18,400     ***

123,000     RUN
 20,000     RUN
  8,000     ***
 26,400     ***

124,000     RUN
 23,000     RUN
  9,200     ***
 35,600     ***

125,000     RUN
 21,000     RUN
  8,400     ***
 44,000     ***

126,000     RUN
 29,000     RUN
 11,600     ***
 55,600     ***

127,000     RUN
 26,000     RUN
 10,400     ***
 66,000     ***

128,000     RUN
 22,000     RUN
  8,800     ***
 74,800     ***

129,000     RUN
 14,000     RUN
  5,600     ***
 80,400     ***

130,000     RUN
 15,000     RUN
  6,000     ***
 86,400     ***

131,000     RUN
 10,000     RUN
  4,000     ***
 90,400     ***

132,000     RUN
  7,000     RUN
  2,800     ***
 93,200     ***

133,000     RUN
  5,000     RUN
  2,000     ***
 95,200     ***

(error)
134,000     RUN
 15,000     RUN
  6,000     ***
101,200     ***

            XEQ E
134,000     RUN
 15,000     RUN
134,000     RUN
  5,000     RUN
  2,000     ***
 97,200     ***

135,000     RUN
  4,000     RUN
  1,600     ***
 98,800     ***

136,000     RUN
  3,000     RUN
  1,200     ***
100,000     ***

            XEQ D
N=250,000
MOY.=126,096
D.S.=3,994
g1=0,185
g2=-0,173
```

(*) PHILIPPE p.6

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA


```
01♦LBL "HIST"
02 CLRG
03 CF 00
04 CF 01
05 RTN
06♦LBL C
07 SF 00
08 RTN
09♦LBL B
10 SF 01
11 STOP
12 STO 08
13 ADV
14 GTO 01
15♦LBL A
16 STOP
17 STO 07
18 STOP
19 STO 09
20 ADV
21♦LBL 01
22 0
23 STO 10
24 5
25 STO 13
26 XEQ 02
27 FS? 01
28 XEQ 06
29♦LBL 03
30 RCL 05
31 ST+ IND 10
32 RCL 06
33 *
34 STO 05
35 1
36 ST+ 10
37 ST- 13
38 RCL 13
39 X>0?
40 GTO 03
41 FS? 01
42 GTO 01
43 RCL 06
44 RCL 07
45 -
46 RCL 09
47 /
48 20
49 +
50 STO 16
51 1
52 ST+ IND 16
53 GTO 01
54♦LBL 02
55 STOP
56 FS? 00
57 LOG
58 STO 06
59 1
60 FS? 01
61 STOP
62 STO 05
63 RTN
64♦LBL 06
65 100
66 *
67 RCL 08
68 /
69 PRX
70 ST+ 11
71 RCL 11
72 PRX
73 ADV
74 RTN
75♦LBL D
76 RCL 01
77 RCL 00
78 "N"
79 XEQ 11
80 /
81 "MOY."
82 XEQ 11
83 RCL 02
84 RCL 01
85 X↑2
86 RCL 00
87 /
88 -
89 RCL 00
90 1
91 -
92 /
93 STO 05
94 SQRT
95 "D.S."
96 XEQ 11
97 STO 06
98 RCL 00
99 RCL 03
100 *
101 3
102 RCL 01
103 RCL 02
104 *
105 *
106 -
107 2
108 RCL 01
109 3
110 Y↑X
111 *
112 RCL 00
113 /
114 +
115 RCL 00
116 1
117 -
118 RCL 00
119 2
120 -
121 *
122 RCL 05
123 RCL 06
124 *
125 STO 05
126 *
127 /
128 "G1"
129 SF 13
130 XEQ 11
131 CF 13
132 RCL 00
133 RCL 04
134 *
135 4
136 RCL 01
137 RCL 03
138 *
139 *
140 -
141 6
142 RCL 01
143 X↑2
144 *
145 RCL 02
146 RCL 00
147 /
148 *
149 +
150 3
151 RCL 01
152 4
153 Y↑X
154 *
155 RCL 00
156 X↑2
157 /
158 -
159 RCL 00
160 1
161 +
162 *
163 RCL 00
164 1
165 -
166 /
167 RCL 00
168 2
169 -
170 /
171 RCL 00
172 3
173 -
174 /
175 RCL 05
176 RCL 06
177 *
178 /
179 3
180 RCL 00
181 1
182 -
183 X↑2
184 *
185 RCL 00
186 2
187 -
188 /
189 RCL 00
190 3
191 -
192 /
193 -
194 "G2"
195 SF 13
196 XEQ 11
197 CF 13
198 FS? 01
199 GTO 04
200 20
201 STO 10
202 0
203 STO 04
204 STO 03
205 RCL 07
206 RCL 09
207 2
208 /
209 +
210 STO 07
211♦LBL 05
212 ADV
213 RCL 03
214 RCL 09
215 *
216 RCL 07
217 +
218 PRX
219 RCL IND 10
220 "F"
221 SF 13
222 XEQ 11
223 CF 13
224 100
225 *
226 RCL 00
227 /
228 "F%"
229 SF 13
230 XEQ 11
231 CF 13
232 ST+ 04
233 1
234 ST+ 03
235 ST+ 10
236 RCL 04
237 "ΣF%"
238 SF 13
239 XEQ 11
240 CF 13
241 100
242 X=Y?
243 GTO 04
244 GTO 05
245♦LBL 04
246♦LBL E
247 0
248 STO 10
249 5
250 STO 13
251 XEQ 02
252 FC? 01
253 GTO 08
254 100
255 *
256 RCL 08
257 /
258 ST- 11
259♦LBL 08
260♦LBL 07
261 RCL 05
262 ST- IND 10
263 RCL 06
264 *.
265 STO 05
266 1
267 ST+ 10
268 ST- 13
269 RCL 13
270 X>0?
271 GTO 07
272 FS? 01
273 GTO 01
274 RCL 06
275 RCL 07
276 -
277 RCL 09
278 /
279 20
280 +
281 STO 16
282 1
283 ST- IND 16
284 GTO 01
285♦LBL 11
```

Please use paper glue to attach listings. Adhesive tape may affect print!
Bitte Listings mit Papierleim einkleben. Klebefilme können Druck bleichen!

S.V.P. utilisez de la colle à papier pour fixer les listings. Les rubans adhésifs peuvent altérer l'impression!
Per favore usare la colla per fissare i listati. Il nastro adesivo puo alterare lo stampato!

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.02

```
286 "├="
287 ARCL X
288 AVIEW
289 RTN
290 ADV
291 END
```

Please use paper glue to attach listings. Adhesive tape may affect print!
Bitte Listings mit Papierleim einkleben. Klebefilme können Druck bleichen!

S.V.P. utilisez de la colle à papier pour fixer les listings. Les rubans adhésifs peuvent altérer l'impression!
Per favore usare la colla per fissare i listati. Il nastro adesivo puo alterare lo stampato!

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers
Datenspeicher
Registres de données
Registri

00	Σf	50	
	Σfy		
	Σfy^2		
	Σfy^3		
	Σfy^4		
05	13	55	
	y or log.y		
	y_0		
	N		
	L		
10	0	60	
	$\Sigma f\%$		
	5		
15		65	
	class midpoint		
20	to 50	70	
	f in cells		
25		75	
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 050 Total Reg. _____ **User Mode**

Eng ☐ Fix ☒ Sci ☐ On ☒

Deg ☐ Rad ☐ Grad ☐ Off ☐

Purpose (Bedeutung / Signification / Scopo)		Flags SET	Flags CLEAR
00	Log transform	X	
01	Grouped data	X	
02			
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
28	Decimal Point		
29	Digit Grouping		

Assignments
Tastenbelegung/Assignations/Assegnamenti

Function (Funktion / Fonction / Funzione)	Key (Taste / Touche / Tasto)	Function (Funktion / Fonction / Funzione)	Key (Taste / Touche / Tasto)

STAT.03

TWO INDEPENDANT SAMPLES

1 - COMPARISON OF VARIANCES : "F" TEST

2 - COMPARISON OF MEANS : "t" TEST

DESCRIPTION

Two independant samples, with size n_1 and n_2, are compared.

1 - Comparison of variances.

The two variances are estimated from the data, as s_1^2 and s_2^2.

H_0 : the two variances are estimations of the same variance σ^2

H_1 : the two variances are différent : $\sigma_1^2 \neq \sigma_2^2$

$F = s_1^2/s_2^2$ (or s_2^2/s_1^2) using the largest variance as the numerator. The program display the probability $P_{(F)}$ (two-tailed test)

2 - Comparison of means.

H_0 : the two samples come from the same population (μ, σ)

H_1 : the two samples come from two populations with means μ_1 and μ_2, but with the same variance σ^2

$H_{1(a)}$: $\mu_1 \neq \mu_2$ (two-tailed test)

$H_{1(b)}$: $\mu_1 > \mu_2$ or $\mu_1 < \mu_2$ (one-tailed test)

If F is not significant, the Student's "t" test is appropriate :

$$t = \frac{|\bar{y}_1 - \bar{y}_2|}{s_{comb}\sqrt{1/n_1 + 1/n_2}}$$ with $(n_1 + n_2 - 2)$ degrees of freedom

If F is significant ($P < 0,05$), the Student's "t"test is not convenient; the program computes :

$$t' = \frac{|\bar{y}_1 - \bar{y}_2|}{\sqrt{s_1^2/n_1 + s_2^2/n_2}}$$ with a number of d.f. such as

$$\frac{1}{f} = \frac{c^2}{n_1 - 1} + \frac{(1-c)^2}{n_2 - 1}, \quad \text{with} \quad c = \frac{s_1^2}{n_1} \Big/ \left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)$$

The user selects the two-tailed or the one-tailed test, and the program displays the probability $P_{(t)}$. If P is lower than the chosen significance level, the difference $|\bar{y}_1 - \bar{y}_2|$ is significant.

USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

Step Schritt Pas Passo	**Instructions** Operation Instructions Istruzioni	**Variables** Dateneingabe Données Dati	**Function(s)** Taste(n) Touche(s) Tasti	**Result** Resultat Résultat Risultato
1	Key in the program STAT.03, tracks 1 to 5			
2	Initialize		XEQ"ECH.IND."	
3	Input the data of the first sample	y_i	R/S	
4	Correction routine			
	Call		E	
	Input the erroneous y	y_E	R/S	
	then the correct one	y_C	R/S	
5	At the end of the sample,			
	Call		B	
	Display : mean y			MOY
6	Repeat steps 3 to 5 for the second sample			
7	"F" test			
	Display : value of F			F
	degrees of freedom 1			D.L.$_1$
	degrees of freedom 2			D.L.$_2$
	probability P(F)			P
8	"t" test			
	If P(F) < 0,05, t' is computed instead of t			
	Display : value of t or t'			t
	number of d.f.			D.L.
9	For a one-tailed test, call		p.A	
	For a two-tailed test, call		p.B	
	Display : probability P(t)			P
10	For another set of data, call and return to step 3		A	

EXAMPLE 1 - F non significant (*)

	XEQ "ECHIND"				
	146,30 RUN		146,60 RUN		F=2,07
	140,50 RUN		143,00 RUN		DL1=6,00
	143,00 RUN		145,30 RUN		DL2=9,00
	143,90 RUN		149,50 RUN		P=0,157
	142,00 RUN		144,10 RUN		
(error)	1.141,50 RUN		149,40 RUN		t=3,04
	141,60 RUN		144,00 RUN		DL=15,00
	143,20 RUN		XEQ B		XEQ b
	144,50 RUN		145,99 ***		P=0,008
	140,70 RUN				
	XEQ E				
	1.141,50 RUN				
	141,50 RUN				
	XEQ B				
	142,72 ***				

EXAMPLE 2 - F significant

	XEQ A		338,00 RUN		F=3,02
	348,00 RUN		350,00 RUN		DL1=17,00
	345,00 RUN		335,00 RUN		DL2=17,00
	350,00 RUN		333,00 RUN		P=0,014
	344,00 RUN		345,00 RUN		
	342,00 RUN		331,00 RUN		t=3,14
	346,00 RUN		354,00 RUN		DL=27,15
	349,00 RUN		339,00 RUN		XEQ b
	345,00 RUN		339,00 RUN		P=0,004
	341,00 RUN		343,00 RUN		
	347,00 RUN		347,00 RUN		
	344,00 RUN		340,00 RUN		
	339,00 RUN		336,00 RUN		
	341,00 RUN		342,00 RUN		
	348,00 RUN		345,00 RUN		
	352,00 RUN		338,00 RUN		
	345,00 RUN		335,00 RUN		
	346,00 RUN		339,00 RUN		
	349,00 RUN		XEQ B		
	XEQ B		340,50 ***		
	345,61 ***				

(*) PHILIPPE p.40

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA


```
01♦LBL "ECHIND"
02♦LBL A
03 CLRG
04 CF 00
05♦LBL 01
06 STOP
07 Σ+
08 GTO 01
09♦LBL B
10 XEQ 02
11 1
12 -
13 XEQ 02
14 MEAN
15 PRX
16 ADV
17 XEQ 02
18 SDEV
19 X↑2
20 XEQ 02
21 CLΣ
22 4
23 RCL 25
24 X=Y?
25 GTO 01
26 RCL 07
27 RCL 03
28 X>Y?
29 GTO 03
30 /
31 "F"
32 XEQ 19
33 STO 08
34 RCL 05
35 "DL1"
36 XEQ 19
37 STO 09
38 RCL 01
39 "DL2"
40 XEQ 19
41 STO 10
42 XEQ 05
43 GTO 04
44♦LBL 03
45 X<>Y
46 /
47 "F"
48 XEQ 19
49 STO 08
50 RCL 01
51 "DL1"
52 XEQ 19
53 STO 09
54 RCL 05
55 "DL2"
56 XEQ 19
57 STO 10
58 XEQ 05
59♦LBL 04
60 RTN
61♦LBL 05
62 2
63 ENTER↑
64 9
65 /
66 STO 17
67 RCL 09
68 /
69 STO 18
70 RCL 17
71 RCL 10
72 /
73 STO 17
74 1
75 -
76 CHS
77 RCL 08
78 3
79 1/X
80 Y↑X
81 *
82 1
83 RCL 18
84 -
85 -
86 STO 19
87 RCL 17
88 RCL 08
89 2
90 ENTER↑
91 3
92 /
93 Y↑X
94 *
95 RCL 18
96 +
97 SQRT
98 RCL 19
99 X<>Y
100 /
101 STO 20
102 X>0?
103 SF 02
104 ABS
105 1
106 RCL 20
107 .196854
108 *
109 +
110 RCL 20
111 X↑2
112 .115194
113 *
114 +
115 RCL 20
116 3
117 Y↑X
118 .000344
119 *
120 +
121 RCL 20
122 4
123 Y↑X
124 .019527
125 *
126 +
127 -4
128 Y↑X
129 2
130 /
131 CHS
132 1
133 +
134 FS?C 02
135 XEQ 06
136 FIX 3
137 "P"
138 XEQ 19
139 FIX 2
140 ADV
141 .05
142 X<=Y?
143 GTO C
144 GTO D
145 RTN
146♦LBL 06
147 1
148 X<>Y
149 -
150 RTN
151♦LBL 02
152 STO IND 25
153 ?ISZ
154 RTN
155♦LBL E
156 STOP
157 Σ-
158 GTO 01
159♦LBL D
160 SF 00
161♦LBL C
162 FS? 00
163 GTO 07
164 RCL 01
165 RCL 03
166 *
167 RCL 05
168 RCL 07
169 *
170 +
171 RCL 01
172 RCL 05
173 +
174 /
175 RCL 00
176 1/X
177 RCL 04
178 1/X
179 +
180 *
181 SQRT
182 STO 08
183 GTO 08
184♦LBL 07
185 RCL 03
186 RCL 00
187 /
188 RCL 07
189 RCL 04
190 /
191 +
192 SQRT
193 STO 08
194♦LBL 08
195 RCL 02
196 RCL 06
197 -
198 ABS
199 RCL 08
200 /
201 SF 13
202 "T"
203 XEQ 19
204 CF 13
205 STO 10
206 FS? 00
207 GTO 09
208 RCL 01
209 RCL 05
210 +
211 STO 09
212 "DL"
213 XEQ 19
214 GTO 10
215♦LBL 09
216 RCL 03
217 RCL 00
218 /
219 STO 11
220 RCL 07
221 RCL 04
222 /
223 +
224 RCL 11
225 X<>Y
226 /
227 STO 11
228 X↑2
229 RCL 01
230 /
231 1
232 RCL 11
233 -
234 X↑2
235 RCL 05
236 /
237 +
238 1/X
239 STO 09
240 "DL"
241 XEQ 19
242♦LBL 10
243 RTN
244♦LBL a
245 SF 02
246♦LBL b
247 RCL 10
248 ABS
249 RCL 09
250 RAD
251 SQRT
252 /
253 ATAN
254 STO 02
255 RCL 09
256 ?
257 /
258 INT
259 LASTX
260 X≠Y?
261 GTO 11
262 0
263 STO 05
264♦LBL 16
265 RCL 02
266 COS
267 X↑2
268 STO 03
269 RCL 02
270 SIN
271 STO 04
272 RCL 09
273 2
274 X=Y?
275 GTO 14
276 /
277 1
278 -
279 STO 25
280 1
281 STO 06
282♦LBL 12
283 RCL 03
284 *
285 RCL 05
```

Please use paper glue to attach listings. Adhesive tape may affect print!
Bitte Listings mit Papierleim einkleben. Klebefilme können Druck bleichen!

S.V.P. utilisez de la colle à papier pour fixer les listings. Les rubans adhésifs peuvent altérer l'impression!
Per favore usare la colla per fissare i listati. Il nastro adesivo puo alterare lo stampato!

STAT.03

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

```
286 1
287 +
288 *
289 LASTX
290 1
291 +
292 STO 05
293 /
294 ST+ 06
295 7DSZ
296 GTO 12
297 RCL 06
298 RCL 04
299 *
300 FS? 01
301 GTO 18
302 GTO 13
303◆LBL 18
304 RTN
305◆LBL 11
306 RCL 02
307 2
308 *
309 PI
310 /
311 STO 07
312 3
313 RCL 09
314 X=Y?
315 GTO 20
316 1
317 STO 05
318 ST- 09
319 X=Y?
320 GTO 15
321 SF 01
322 XEQ 16
323 CF 01
324◆LBL 21
325 RCL 02
326 COS
327 *
328 2
329 *
330 PI
331 /
332 RCL 07
333 +
334 GTO 13
335 RTN
336◆LBL 15
337 RCL 07
338 GTO 13
339◆LBL 14
340 RCL 04
341 GTO 13
342 RTN
343◆LBL 13
344 1
345 X<>Y
346 -
347 FS?C 02
348 XEQ 17
349 FIX 3
350 "P="
351 XEQ 19
352 FIX 2
353 RTN
354◆LBL 17
355 2
356 /
357 RTN
358◆LBL 20
359 RCL 02
360 SIN
361 GTO 21
362 RTN
363◆LBL 19
364 "├="
365 ARCL X
366 AVIEW
367 RTN
368 END
```

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers
Datenspeicher
Registres de données
Registri

00	n_1	50	
	$n_1 - 1$		
	$mean_1$		
	$var._1$		
	n_2		
05	$n_2 - 1$	55	
	$mean_2$		
	$var._2$		
	F		
	$d.f._1$		
10	$d.f._2$	60	

15	statistical	65	
	stack		

20		70	
25	ISZ reg.	75	
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 026 Total Reg. _____

Eng	☐	Fix	☒	Sci	☐
Deg	☐	Rad	☒	Grad	☐

User Mode: On ☒ Off ☐

Purpose
Bedeutung
Signification
Scopo

Flags

		SET	CLEAR
00	t' test	X	
01	one-tailed test	X	
02	P(t) routine	X	
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
28	Decimal Point		
29	Digit Grouping		

Assignments
Tastenbelegung/Assignations/Assegnamenti

Function (Funktion / Fonction / Funzione)	Key (Taste / Touche / Tasto)	Function (Funktion / Fonction / Funzione)	Key (Taste / Touche / Tasto)

INTRODUCTION

This HP-41C Solutions book was written to help you get the most from your calculator. The programs were chosen to provide useful calculations for many of the common problems encountered.

They will provide you with immediate capabilities in your everyday calculations and you will find them useful as guides to programming techniques for writing your own customized software. The comments on each program listing describe the approach used to reach the solution and help you follow the programmer's logic as you become and expert on your HP calculator.

KEYING A PROGRAM INTO THE HP-41C

There are several things that you should keep in mind while you are keying in programs from the program listings provided in this book. The output from the HP 82143A printer provides a convenient way of listing and an easily understood method of keying in programs without showing every keystroke. This type of output is what appears in this handbook. Once you understand the procedure for keying programs in from the printed listings, you will find this method simple and fast. Here is the procedure:

1. At the end of each program listing is a listing of status information required to properly execute that program. Included is the SIZE allocation required. Before you begin keying in the program, press [XEQ] [ALPHA] SIZE [ALPHA] and specify the allocation (three digits; e.g., 10 should be specified as 010).

   Also included in the status information is the display format and status of flags important to the program. To ensure proper execution, check to see that the display status of the HP-41C is set as specified and check to see that all applicable flags are set or clear as specified.

2. Set the HP-41C to PRGM mode (press the [PRGM] key) and press [■] [GTO] [•] [•] to prepare the calculator for the new program.

3. Begin keying in the program. Following is a list of hints that will help you when you key in your programs from the program listings in this handbook.

   a. When you see " (quote marks) around a character or group of characters in the program listing, those characters are ALPHA. To key them in, simply press [ALPHA], key in the characters, then press [ALPHA] again. So "SAMPLE" would be keyed in as [ALPHA] "SAMPLE" [ALPHA].

   b. The diamond in front of each LBL instruction is only a visual aid to help you locate labels in the program listings. When you key in a program, ignore the diamond.

   c. The printer indication of divide sign is /. When you see / in the program listing, press [÷].

   d. The printer indication of the multiply sign is ⋇. When you see ⋇ in the program listing, press [×].

   e. The ⊢ character in the program listing is an indication of the [APPEND] function. When you see ⊢, press [■] [APPEND] in ALPHA mode (press [■] and the K key).

   f. All operations requiring register addresses accept those addresses in these forms:

      nn (a two-digit number)
      IND nn (INDIRECT: [■], followed fy a two-digit number)
      X, Y, Z, T, or L (a STACK address: [•] followed by X, Y, Z, T, or L)
      IND X, Y, Z, T or L (INDIRECT stack: [■] [•] followed by X, Y, Z, T, or L)

      Indirect addresses are specified by pressing [■] and then the indirect address. Stack addresses are specified by pressing [•] followed by X, Y, Z, T, or L. Indirect stack addresses are specified by pressing [■] [•] and X, Y, Z, T, or L.

Printer Listing	Keystrokes	Display
01◆LBL "SAMPLE"	[■] [LBL] [ALPHA] SAMPLE [ALPHA]	*01 LBL"SAMPLE*
02 "THIS IS A "	[ALPHA] *THIS IS A* [ALPHA]	*02"THIS IS A*
03 "⊢SAMPLE"	[ALPHA] [■] [APPEND] SAMPLE	*03" ⊢ SAMPLE*
04 AVIEW	[■] AVIEW [ALPHA]	*04 AVIEW*
05 6	6	*05 6*
06 ENTER↑	[ENTER↑]	*06 ENTER ↑*
07 -2	2 [CHS]	*07 -2*
08 /	[÷]	*08 /*
09 ABS	[XEQ] [ALPHA] ABS [ALPHA]	*09 ABS*
10 STO IND L	[STO] [■] [•] L	*10 STO IND L*
11 "R3="	[ALPHA] R3= [■] [ARCL] 03	*11"R3=*
12 ARCL 03	[■] [AVIEW]	*12 ARCL 03*
13 AVIEW	[ALPHA]	*13 AVIEW*
14 RTN	[■] [RTN]	*14 RTN*

STAT.04

TWO RELATED SAMPLES

"t" TEST FOR PAIRED COMPARISONS

DESCRIPTION

Two samples are considered as paired when, to each measurement in one group corresponds a measurement in the other : this will be the case, for example, when two treatments are applied in sequence to the same unit (patient, animal); or when two analytical methods are used on several lots of material.

The variable used in the test is the difference d between the measurements y_1 and y_2 of each pair. The efficiency of the test is increased by éliminating the variations between the pairs.

The program computes the d_i and the mean $\bar{d}$.

H_0 : the differences d_i have a normal distribution with mean $\mu = 0$ and variance σ_d^2.

H_1 : a- $\mu \neq 0$ (two-tailed test)

b- $\mu > 0$ or $\mu < 0$ (one-tailed test)

The test statistic is :

$$t = \frac{|\bar{d} - 0|}{s_d\sqrt{n}} \quad \text{with } (n - 1) \text{ d.f.}$$

n is the number of pairs.

The program displays the value of "t", the number of degrees of freedom and the probability P(t). If P is lower than the chosen significance level, $\bar{d}$ is significantly different from zero.

USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

STAT.04

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.04, tracks 1 to 3			
2	Initialize		XEQ"ECH.PAIR."	
3	Input the data in pairs	y_1	R/S	
		y_2	R/S	
	Display of $d = y_1 - y_2$			
4	Correction routine			
	If one y is erroneous, enter the complete pair, before calling		E	
	Input the erroneous pair	y_E	R/S	
		y_2	R/S	
	then the correct one			
5	After the last pair, call		B	
	Display of : $\bar{d}$			MOY
	standard error of d			E.S.
	value of "t"			t
	number of d.f.			D.L.
6	For a one-tailed test, call		p.A	
	For a two-tailed test, call		p.B	
	Display of : probability P(t)			P
7	For a new set of data, call and return to step 3.		A	

STAT.04

EXAMPLE 1 - One-tailed test (*)

```
                XEQ "ECHPAIR"                          XEQ B
                985,00    RUN
                990,00    RUN          MOY.=17,22
                 -5,00    ***          E.S.=6,62
                                       t=2,60
               1.015,00    RUN         D.L.=8,00
                980,00    RUN                          XEQ a
                 35,00    ***          P=0,016

   (error)    1.980,00    RUN
                995,00    RUN
                985,00    ***

                      XEQ E
              1.980,00    RUN
                995,00    RUN
                980,00    RUN
                995,00    RUN
                -15,00    ***

              1.000,00    RUN
                995,00    RUN
                  5,00    ***

              1.010,00    RUN
                990,00    RUN
                 20,00    ***

              1.005,00    RUN
                965,00    RUN
                 40,00    ***

                995,00    RUN
                985,00    RUN
                 10,00    ***

              1.020,00    RUN
                995,00    RUN
                 25,00    ***

              1.045,00    RUN
              1.005,00    RUN
                 40,00    ***
```

(*) PHILIPPE pp.37-38

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA


```
01♦LBL "ECHPAIR"
02♦LBL A
03 CLRG
04♦LBL 01
05 STOP
06 STOP
07 -
08 PRX
09 ADV
10 ΣREG 14
11 Σ+
12 GTO 01
13♦LBL B
14 MEAN
15 "MOY."
16 XEQ 11
17 ABS
18 STO 00
19 SDEV
20 RCL 19
21 SQRT
22 /
23 "E.S."
24 XEQ 11
25 RCL 00
26 X<>Y
27 /
28 SF 13
29 "T"
30 XEQ 11
31 CF 13
32 STO 10
33 RCL 19
34 1
35 -
36 STO 09
37 "D.L."
38 XEQ 11
39 RTN
40♦LBL 11
41 "├="
42 ARCL X
43 AVIEW
44 RTN
45♦LBL E
46 STOP
47 STOP
48 -
49 Σ-
50 GTO 01
51♦LBL a
52 SF 02
53♦LBL b
54 RCL 10
55 ABS
56 RCL 09
57 RAD
58 SQRT
59 /
60 ATAN
61 STO 02
62 RCL 09
63 2
64 /
65 INT
66 LASTX
67 X≠Y?
68 GTO 19
69 0
70 STO 05
71♦LBL 16
72 RCL 02
73 COS
74 X↑2
75 STO 03
76 RCL 02
77 SIN
78 STO 04
79 RCL 09
80 2
81 X=Y?
82 GTO 14
83 /
84 1
85 -
86 STO 25
87 1
88 STO 06
89♦LBL 12
90 RCL 03
91 *
92 RCL 05
93 1
94 +
95 *
96 LASTX
97 1
98 +
99 STO 05
100 /
101 ST+ 06
102 ?DSZ
103 GTO 12
104 RCL 06
105 RCL 04
106 *
107 FS? 01
108 GTO 18
109 GTO 13
110♦LBL 18
111 RTN
112♦LBL 19
113 RCL 02
114 2
115 *
116 PI
117 /
118 STO 07
119 3
120 RCL 09
121 X=Y?
122 GTO 20
123 1
124 STO 05
125 ST- 09
126 X=Y?
127 GTO 15
128 SF 01
129 XEQ 16
130 CF 01
131♦LBL 21
132 RCL 02
133 COS
134 *
135 2
136 *
137 PI
138 /
139 RCL 07
140 +
141 GTO 13
142 RTN
143♦LBL 15
144 RCL 07
145 GTO 13
146♦LBL 14
147 RCL 04
148 GTO 13
149 RTN
150♦LBL 13
151 1
152 X<>Y
153 -
154 "FS?C02"
155 XEQ 17
156 FIX 3
157 "P"
158 XEQ 11
159 FIX 2
160 RTN
161♦LBL 17
162 2
163 /
164 RTN
165♦LBL 20
166 RCL 02
167 1
168 RTN
169 END
```

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers
Datenspeicher
Registres de données
Registri

00	d	50	
	routine P(t)		
05		55	
	d.f.		
10		60	
	statistic. stack		
15		65	
20		70	
25	ISZ reg.	75	
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 026 Total Reg. _____ **User Mode**

Eng ☐ Fix ☒ Sci ☐ On ☒

Deg ☐ Rad ☒ Grad ☐ Off ☐

Purpose
Bedeutung
Signification
Scopo

Flags

		SET	CLEAR	
00				
01	P(t) routine	X		
02	One-tailed t.	X		
03				
04				
05				
06				
07				
08				
09				
10				
11	Audio execute			
12				
13				
14				
15				
16				
17				
18				
19				
20				
21	Printer Enable			
22	Number Input			
23	Alpha Input			
24	Range Ignore			
25	Error Ignore			
26	Audio Enable			
27	User Mode			
28	Decimal Point			
29	Digit Grouping			

Assignments
Tastenbelegung/Assignations/Assegnamenti

Function Funktion Fonction Funzione	Key Taste Touche Tasto	Function Funktion Fonction Funzione	Key Taste Touche Tasto

STAT.05

SINGLE CLASSIFICATION ANALYSIS OF VARIANCE

DESCRIPTION

It is a comparison between a samples or groups, equal in size or not, and assumed to be :

a - either sampled randomly from the same normal population (μ, σ^2)

b - or from normal populations with means $\mu_1, \mu_2, \ldots \mu_a$, but with the same variance σ^2.

In the analysis of variance (ANOVA), two estimations of the variance (or mean squares) are computed :

- one based on the within groups variations, obtained as a pooled variance (weighted average of the a variances of the groups) s_1^2
- one computed from the group means or totals (variation among groups) s_2^2

These two mean squares are compared with an "F" test :

$$F = s_2^2 / s_1^2$$

If F is not significant, one can conclude that the a groups come from the same population. If F is significant, i.e. if the mean square among groups s_2^2 is significantly larger than the mean square within groups s_1^2 (experimental error), one can conclude that an extra source of variation, due to a difference between the groups, is added to the variation due to the experimental error.

If the added variation is caused by fixed treatments chosen by the experimenter, it is a Model I ANOVA; the several means can be compared to each other (see Progr. ANOVA 4). If the added variation is a random effect, it is a Model II ANOVA, and the variation due to this effect can be estimated.

The results are generally displayed in the form of an ANOVA table

Source of variation	Nbr D.F.	Sum of Squares	Mean Square	F	P(F)
Among groups	a - 1				
Within groups (error)	N - a				
Total	N - 1				

Since the number of degrees of freedom and the sums of squares are additive, the table is conveniently computed as follows :

- Total S.S. : $\Sigma y^2 - (\Sigma y)^2/N$
- Group S.S. : $\Sigma (T_i/n_i)^2 - (\Sigma y)^2/N$

T_i = sum of the n_i responses in group i.

The program displays the results in the order of the ANOVA table.

-Equality of the variances

For the ANOVA to be valid, the several variances should be equal (homoscedasticity). This can be checked by the Bartlett's test.

$$X^2 = \frac{2,3026}{C} (N' \log s^2 - \Sigma n_i' \log s_i^2)$$

with $C = 1 + \frac{1}{3(a-1)} (\Sigma \frac{1}{n_i'} - \frac{1}{N'})$ n_i' and s_i^2 = d.f. and variance of each sample; N' = total d.f.; s^2 = pooled variance

This statistic X^2 has a chi square distribution with (a - 1) d.f.

If the test is significant, one should try an appropriate transformation of the data, or use a non parametric test.

- Model II ANOVA

If F is significant, one can estimate the percentage of the total variation due to the variation among groups, and the percentage due to the experimental error. When the group size is unequal, n_0 is computed as :

$$n_0 = \frac{1}{a-1} (\Sigma n_i - \frac{\Sigma n_i^2}{\Sigma n_i})$$

USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

STAT.05

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.05, tracks 1 to 6			
2	Initialize		XEQ"ANVA.1"	
3	Enter : number of groups	a	R/S	
4	Input the data of the first group	y_i.....	R/S	
5	At the end of the group, call		B	
	Display : total of the group			Σ
	mean			MOY.
	variance			VAR.
6	Correction routine			
	Before calling B. Call		E	
	input the erroneous y	y_E	R/S	
	then the correct one	y_C		
7	Repeat steps 4 and 5 for the other groups			
	At the end of the last group, display of the ANOVA :			
	Among groups			d.l., S.C., C.M., F, P
	Error			d.l., S.C. C.M.
	Total			d.l.,S.C.
8	Bartlett's test			
	Display of :			χ^2
	nbr d.f.			d.l.
	limit value			$\chi^2_{0,05}$
	ANOVA Model II			
9	Call		C	
	Display of : average size of groups			n_0
	variance groups			VAR.G
	% variance groups			VAR.G %
	% error			VAR.E %
10	For an ANOVA Model I, see Prog. STAT.08			
	For a new set of data, call		A	
	and return to step 3.			

EXAMPLE 1 - ANOVA MODEL I (*)

```
                XEQ A
          3,00   RUN

        118,00   RUN
         85,00   RUN
         80,00   RUN
        102,00   RUN
         75,00   RUN
         65,00   RUN
         86,00   RUN
         73,00   RUN
                XEQ B
Σ=684,00
MOY.=85,50
VAR.=292,29

        120,00   RUN
         97,00   RUN
        103,00   RUN
(error) 1.105,00 RUN
        138,00   RUN
         96,00   RUN
                XEQ E
      1.105,00   RUN
        105,00   RUN
                XEQ B
Σ=659,00
MOY.=109,83
VAR.=264,57

        100,00   RUN
        128,00   RUN
        113,00   RUN
        134,00   RUN
                XEQ B
Σ=475,00
MOY.=118,75
VAR.=234,25
```

```
ANVA
TRAIT
D.L.=2,00
S.C.=3.650,42
C.M.=1.825,21
F=6,72
P=0,008

ERR
D.L.=15,00
S.C.=4.071,58
C.M.=271,44

TOT
D.L.=17,00
S.C.=7.722,00

BART
CHI.2=0,05
D.L.=2,00

CHI.2.0,05=6,02
```

(*) PHILIPPE p.124

EXAMPLE 2I - ANOVA MODEL II (**)

```
              XEQ "ANVA1"
         6,00   RUN

       103,00   RUN
        85,00   RUN
       138,00   RUN
       160,00   RUN
        74,00   RUN
              XEQ B
Σ=560,00
MOY.=112,00
VAR.=1.308,50

       -33,00   RUN
        54,00   RUN
        18,00   RUN
        42,00   RUN
        19,00   RUN
              XEQ B
Σ=100,00
MOY.=20,00
VAR.=1.113,50

        58,00   RUN
       171,00   RUN
       193,00   RUN
       210,00   RUN
        33,00   RUN
              XEQ B
Σ=665,00
MOY.=133,00
VAR.=6.649,50

       170,00   RUN
        96,00   RUN
       112,00   RUN
       151,00   RUN
        11,00   RUN
              XEQ B
Σ=540,00
MOY.=108,00
VAR.=3.815,50
```

(**) PHILIPPE p.115

```
       133,00   RUN
        68,00   RUN
        90,00   RUN
       125,00   RUN
         4,00   RUN
              XEQ B
Σ=420,00
MOY.=84,00
VAR.=2.693,50

        51,00   RUN
       102,00   RUN
        -1,00   RUN
        68,00   RUN
        80,00   RUN
              XEQ B
Σ=300,00
MOY.=60,00
VAR.=1.507,50

ANVA
TRAIT
D.L.=5,00
S.C.=42.024,17
C.M.=8.404,83
F=2,95
P=0,032

ERR
D.L.=24,00
S.C.=68.352,00
C.M.=2.848,00

TOT
D.L.=29,00
S.C.=110.376,17

BART
CHI.2=4,62
D.L.=5,00

CHI.2.0,05=11,08
              XEQ C
n0=5,00
VAR.G=1.111,37
VAR.G%=28,07
VAR.E%=71,93
```

```
01♦LBL "ANVA1"
02♦LBL A
03 CLRG
04 CF 00
05 CF 01
06 STOP
07 STO 20
08 ADV
09 STO 25
10 30.054
11 STO 26
12♦LBL 01
13 STOP
14 ΣREG 14
15 Σ+
16 GTO 01
17♦LBL B
18 RCL 15
19 ST+ 00
20 RCL 14
21 ST+ 01
22 "Σ"
23 XEQ 11
24 RCL 19
25 ST+ 02
26 X↑2
27 ST+ 24
28 MEAN
29 "MOY."
30 XEQ 11
31 SDEV
32 X↑2
33 "VAR."
34 XEQ 11
35 LOG
36 RCL 19
37 1
38 -
39 ST+ 21
40 *
41 ST+ 22
42 LASTX
43 1/X
44 ST+ 23
45 ADV
46 RCL 14
47 X↑2
48 RCL 19
49 /
50 ST+ 03
51 XEQ 10
52 CLΣ
53 7DSZ
54 GTO 01
55 RCL 00
56 RCL 01
57 X↑2
58 RCL 02
59 /
60 STO 01
61 -
62 STO 00
63 "ANVA"
64 AVIEW
65 "TRAIT"
66 AVIEW
67 RCL 03
68 RCL 01
69 -
70 STO 03
71 -
72 STO 04
73 RCL 02
74 RCL 20
75 -
76 STO 06
77 /
78 STO 05
79 RCL 20
80 1
81 -
82 STO 07
83 "D.L."
84 XEQ 11
85 RCL 03
86 "S.C."
87 XEQ 11
88 X<>Y
89 /
90 "C.M."
91 XEQ 11
92 RCL 05
93 /
94 "F"
95 STO 08
96 XEQ 11
97 2
98 ENTER↑
99 9
100 /
101 STO 01
102 RCL 07
103 /
104 STO 09
105 RCL 01
106 RCL 06
107 /
108 STO 01
109 1
110 -
111 CHS
112 RCL 08
113 3
114 1/X
115 Y↑X
116 *
117 1
118 RCL 09
119 -
120 -
121 STO 07
122 RCL 01
123 RCL 08
124 2
125 ENTER↑
126 3
127 /
128 Y↑X
129 *
130 RCL 09
131 +
132 SQRT
133 RCL 07
134 X<>Y
135 /
136 STO 08
137 X>0?
138 SF 02
139 ABS
140 1
141 RCL 08
142 .196854
143 *
144 +
145 RCL 08
146 X↑2
147 .115194
148 *
149 +
150 RCL 08
151 3
152 Y↑X
153 .000344
154 *
155 +
156 RCL 08
157 4
158 Y↑X
159 .019527
160 *
161 +
162 -4
163 Y↑X
164 2
165 /
166 CHS
167 1
168 +
169 FS?C 02
170 XEQ 02
171 FIX 3
172 "P"
173 XEQ 11
174 FIX 2
175 ADV
176 "ERR"
177 AVIEW
178 RCL 06
179 "D.L."
180 XEQ 11
181 RCL 04
182 "S.C."
183 XEQ 11
184 RCL 05
185 "C.M."
186 XEQ 11
187 ADV
188 "TOT"
189 AVIEW
190 RCL 02
191 1
192 -
193 "D.L."
194 XEQ 11
195 RCL 00
196 "S.C."
197 XEQ 11
198 ADV
199 "BART"
200 AVIEW
201 RCL 05
202 LOG
203 RCL 06
204 *
205 RCL 22
206 -
207 RCL 20
208 1
209 -
210 STO 25
211 3
212 *
213 1/X
214 RCL 23
215 RCL 21
216 1/X
217 -
218 *
219 1
220 +
221 2.3026
222 X<>Y
223 /
224 *
225 "CHI.2"
226 XEQ 11
227 RCL 25
228 "D.L."
229 XEQ 11
230 ADV
231 2.518232
232 RCL 25
233 1.282189
234 *
235 +
236 RCL 25
237 X↑2
238 -.00211427
239 *
240 +
241 RCL 25
242 LN
243 1.371169
244 *
245 +
246 "CHI.2.0.05"
247 XEQ 11
248 RTN
249♦LBL 10
250 RCL 14
251 STO IND 26
252 ISG 26
253 RCL 19
254 STO IND 26
255 ISG 26
256 RTN
257♦LBL C
258 RCL 20
259 1
260 -
261 1/X
262 RCL 02
263 RCL 24
264 RCL 02
265 /
266 -
267 *
268 SF 13
269 "N0"
270 XEQ 11
271 STO 06
272 CF 13
273 RCL 03
274 RCL 20
275 1
276 -
277 /
278 RCL 05
279 -
280 RCL 06
281 /
282 "VAR.G"
283 XEQ 11
284 ENTER↑
285 ENTER↑
```

CONTENTS

VOLUME I

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

```
286 RCL 05
287 +
288 1/X
289 *
290 100
291 *
292 "VAR.G%"
293 XEQ 11
294 100
295 -
296 CHS
297 "VAR.E%"
298 XEQ 11
299 RTN
300♦LBL E
301 STOP
302 Σ-
303 GTO 01
304♦LBL 11
305 "⊢="
306 ARCL X
307 AVIEW
308 RTN
309♦LBL 02
310 1
311 X<>Y
312 -
313 RTN
314 END
```

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers
Datenspeicher
Registres de données
Registri

00	Σy^2	50	
	Σy		
	Σn		
	S.C. group		
	S.C. error		
05	var. error	55	
	d.l. error		
	(a - 1)		
	F		
10		60	
	statistic.		
15	stack	65	
20	a	70	
	d.l.		
	n'log s^2		
	1/n'		
25	a	75	
	30		
30	T_i	80	
	n_i		
	•		
	•		
	•		
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 055 Total Reg. _____ **User Mode**

Eng ☐ Fix ☒ Sci ☐ On ☒

Deg ☐ Rad ☐ Grad ☐ Off ☐

Purpose / Flags
Bedeutung
Signification
Scopo

		SET	CLEAR	
00				
01				
02	Routine P(F)	X		
03				
04				
05				
06				
07				
08				
09				
10				
11	Audio execute			
12				
13				
14				
15				
16				
17				
18				
19				
20				
21	Printer Enable			
22	Number Input			
23	Alpha Input			
24	Range Ignore			
25	Error Ignore			
26	Audio Enable			
27	User Mode			
28	Decimal Point			
29	Digit Grouping			

Assignments
Tastenbelegung/Assignations/Assegnamenti

Function Funktion Fonction Funzione	Key Taste Touche Tasto	Function Funktion Fonction Funzione	Key Taste Touche Tasto

STAT.06

RANDOMIZED COMPLETE BLOCKS ANALYSIS OF VARIANCE

DESCRIPTION

In this design, originally devised in agricultural research, the several treatments are applied to plots of land (or blocks), the treatments in each plot being assigned randomly. It is thus possible, in the ANOVA, to substract from the experimental error the variation between plots.

The same design has also numerous applications in other fields: for example, each block may be an individual (patient or animal) receiving several treatments one after another; or a piece of equipment in which several experiments are performed.

There are a treatments ($a \leqslant 12$; when $a > 12$, display : ERROR), with b blocks, and each treatment once in every block. The ANOVA table is :

Source of variation	Number of d.f.	Sum of squares	Mean square	F	P(F)
Between blocks	(b - 1)				
Between treatments	(a - 1)				
Error	(a-1)(b-1)				
Total	(ab - 1)				

The program computes :

- Total sum of squares : $\sum y^2 - C.F.$
- Block sum of squares : $\sum T_b^2/a - C.F.$
- Treatment S.S. : $\sum T_a^2/b - C.F$

C.F. = correction factor = $(\sum y)^2/ab$

T_a = sum of treatments

T_b = sum of blocks

If F = M.S. treat./M.S. error is significant, the treatments can be compared using Program STAT.08.

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in the program STAT.06, tracks			
	1 to 5			
2	Initialize		XEQ"ANVA.2"	
3	Enter : number of treatments	a	R/S	
	number of blocks	b	R/S	
4	Input the data of the first block	$y_1 \ldots$	R/S	
5	At the end of the block, call		B	
	Display: Total of the bloc T_b			ΣB
6	Correction routine			
	a - to correct an erroneous y just			
	entered, call		E	
	input the erroneous y	y_E	R/S	
	then the correct one	y_C	R/S	
	b - if several y have been input			
	after y_E (but before calling B)			
	call		p.E	
	enter the number of the treatment	1 to a	R/S	
	the erroneous y	y_E	R/S	
	then the correct one	y_C	R/S	
7	Repeat steps 4 and 5 for the other blocks			
8	At the end of the last block,			
	display of the ANOVA			
9	If F(treatment) is significant,			
	use STAT.08			
	For another set of data, call		A	
	and go to step 3			

STAT.06

EXAMPLE 1 (*)

```
                XEQ "ANVA2"
                5.00    RUN
                5.00    RUN

                8.00    RUN
                2.00    RUN
                4.00    RUN
                3.00    RUN
                9.00    RUN
                     XEQ B
Σ.B=26.00

               10.00    RUN
                6.00    RUN
               10.00    RUN
                5.00    RUN
                7.00    RUN
                     XEQ B
Σ.B=38.00

               12.00    RUN
                7.00    RUN
                9.00    RUN
                9.00    RUN
(error)        15.00    RUN
                     XEQ E
               15.00    RUN
                5.00    RUN
                     XEQ B
Σ.B=42.00

               13.00    RUN
(error)       111.00    RUN
                8.00    RUN
               10.00    RUN
                5.00    RUN
                     XEQ e
                2.00    RUN
              111.00    RUN
               11.00    RUN
                     XEQ B
Σ.B=47.00

               11.00    RUN
                5.00    RUN
               10.00    RUN
                6.00    RUN
                3.00    RUN
                     XEQ B
Σ.B=35.00
```

```
Σ.T=54.00
MOY.=10.80
Σ.T=31.00
MOY.=6.20
Σ.T=41.00
MOY.=8.20
Σ.T=33.00
MOY.=6.60
Σ.T=29.00
MOY.=5.80

ANVA
BLOC
D.L.=4.00
S.C.=49.84
C.M.=12.46
F.=2.30
P=0.103

TRAIT
D.L.=4.00
S.C.=83.84
C.M.=20.96
F.=3.87
P=0.022

ERR.
D.L.=16.00
S.C.=86.56
C.M.=5.41

TOT.
D.L.=24.00
S.C.=220.24
```

(*) SNEDECOR p.335

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA


```
01♦LBL "ANVA2"
02♦LBL A
03 CLRG
04 STOP
05 STO 20
06 13
07 X<=Y?
08 GTO 09
09 STOP
10 STO 21
11 30.054
12 STO 27
13 ADV
14♦LBL 01
15 STOP
16 ST+ IND 25
17 ?ISZ
18 ΣREG 14
19 Σ+
20 GTO 01
21♦LBL B
22 RCL 15
23 ST+ 13
24 RCL 14
25 ST+ 22
26 "Σ.B"
27 XEQ 11
28 ADV
29 X↑2
30 ST+ 23
31 CLΣ
32 0
33 STO 25
34 1
35 ST+ 24
36 RCL 21
37 RCL 24
38 X≠Y?
39 GTO 01
40 0
41 STO 24
42♦LBL 02
43 RCL IND 25
44 "Σ.T"
45 XEQ 11
46 RCL 21
47 /
48 "MOY."
49 XEQ 11
50 RCL IND 25
51 X↑2
52 ST+ 24
53 XEQ 10
54 ?ISZ
55 RCL 20
56 RCL 25
57 X≠Y?
58 GTO 02
59 RCL 22
60 X↑2
61 RCL 20
62 RCL 21
63 *
64 /
65 STO 22
66 RCL 13
67 RCL 22
68 -
69 STO 13
70 RCL 23
71 RCL 20
72 /
73 RCL 22
74 -
75 STO 23
76 RCL 24
77 RCL 21
78 /
79 RCL 22
80 -
81 STO 24
82 RCL 13
83 RCL 23
84 RCL 24
85 +
86 -
87 STO 14
88 RCL 20
89 1
90 -
91 RCL 21
92 1
93 -
94 *
95 STO 06
96 /
97 STO 05
98 ADV
99 23
100 STO 25
101 "ANVA"
102 AVIEW
103 "BLOC"
104 AVIEW
105 RCL 21
106 1
107 -
108 STO 00
109 XEQ 05
110 ?ISZ
111 "TRAIT"
112 AVIEW
113 RCL 20
114 1
115 -
116 STO 00
117 XEQ 05
118 "ERR."
119 AVIEW
120 RCL 06
121 "D.L."
122 XEQ 11
123 RCL 14
124 "S.C."
125 XEQ 11
126 RCL 05
127 "C.M."
128 XEQ 11
129 ADV
130 "TOT."
131 AVIEW
132 RCL 20
133 RCL 21
134 *
135 1
136 -
137 "D.L."
138 XEQ 11
139 RCL 13
140 "S.C."
141 XEQ 11
142 RTN
143♦LBL 05
144 "D.L."
145 XEQ 11
146 RCL IND 25
147 "S.C."
148 XEQ 11
149 X<>Y
150 /
151 "C.M."
152 XEQ 11
153 RCL 05
154 /
155 STO 17
156 "F."
157 XEQ 11
158 XEQ 03
159 RTN
160♦LBL 03
161 2
162 ENTER↑
163 9
164 /
165 STO 01
166 RCL 00
167 /
168 STO 03
169 RCL 01
170 RCL 06
171 /
172 STO 01
173 1
174 -
175 CHS
176 RCL 17
177 3
178 1/X
179 Y↑X
180 *
181 1
182 RCL 03
183 -
184 -
185 STO 07
186 RCL 01
187 RCL 17
188 2
189 ENTER↑
190 3
191 /
192 Y↑X
193 *
194 RCL 03
195 +
196 SQRT
197 RCL 07
198 X<>Y
199 /
200 STO 08
201 X>0?
202 SF 02
203 ABS
204 1
205 RCL 08
206 .196854
207 *
208 +
209 RCL 08
210 X↑2
211 .115194
212 *
213 +
214 RCL 08
215 3
216 Y↑X
217 .000344
218 *
219 +
220 RCL 08
221 4
222 Y↑X
223 .019527
224 *
225 +
226 -4
227 Y↑X
228 2
229 /
230 CHS
231 1
232 +
233 7DSP3
234 FS?C 02
235 XEQ 04
236 "P"
237 XEQ 11
238 7DSP2
239 ADV
240 RTN
241♦LBL 04
242 1
243 X<>Y
244 -
245 RTN
246♦LBL 10
247 RCL IND 25
248 STO IND 27
249 ISG 27
250 RCL 21
251 STO IND 27
252 ISG 27
253 RTN
254♦LBL 11
255 "⊢="
256 ARCL X
257 AVIEW
258 RTN
259♦LBL E
260 RCL 25
261 1
262 -
263 STO 25
264 STOP
265 ST- IND 25
266 Σ-
267 GTO 01
268♦LBL e
269 STOP
270 ENTER↑
271 1
272 -
273 STO 26
274 STOP
275 ST- IND 26
276 Σ-
277 STOP
278 ST+ IND 26
279 Σ+
280 GTO 01
281 .END.
```

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers
Datenspeicher
Registres de données
Registri

00	T_a	50	
	•		
	•		
	•		
05	Error M.S.	55	
	Error d.f.		
10		60	

	Total S.S.		
	Error S.S.		
15	Statist.stack	65	

20	a	70	
	b		
	C.F.		
	Treat. S.S.		
	Blocks S.S.		
25		75	

	Data for		
	Progr.STAT.08		
	•		
30	•	80	
	•		
	•		
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 055 Total Reg. _____

Eng ☐ Fix ☒ Sci ☐
Deg ☐ Rad ☐ Grad ☐

User Mode
On ☒
Off ☐

Purpose / Flags
Bedeutung
Signification
Scopo

		SET	CLEAR	
00				
01				
02	P(F) routine	X		
03				
04				
05				
06				
07				
08				
09				
10				
11	Audio execute			
12				
13				
14				
15				
16				
17				
18				
19				
20				
21	Printer Enable			
22	Number Input			
23	Alpha Input			
24	Range Ignore			
25	Error Ignore			
26	Audio Enable			
27	User Mode			
28	Decimal Point			
29	Digit Grouping			

Assignments
Tastenbelegung/Assignations/Assegnamenti

Function Funktion Fonction Funzione	Key Taste Touche Tasto	Function Funktion Fonction Funzione	Key Taste Touche Tasto

LATIN SQUARE ANALYSIS OF VARIANCE

DESCRIPTION

In this design, used in agricultural research, a factor is tested at n levels, and the field is divided in n row blocks and in n column blocks. Each level of the factor (treatment) is replicated only once in a given row or column. In the ANOVA, the variations due to rows and columns are eliminated from the error mean square. This design need not be restricted to agricultural research. For instance, the columns may be the subjects and the rows the order of administration of the treatments. This program can accomodate up to a 12 x 12 latin square. (If the number of treatments is larger than 12, a sign ERROR is displayed).

The ANOVA is the following :

Source of variation	Nber d.f.	Sum of squares	Mean square	F	P(F)
Between rows	(n - 1)				
Between columns	(n - 1)				
Between treatments	(n - 1)				
Error	(n-1)(n-2)				
Total	$(n^2 - 1)$				

The data are entered in rows and by pair : first, the number of the treatment (the treatments are numbered : 1, 2, 3..... 12), then the corresponding response. The sums of rows T_r are displayed, then the sums of columns T_c and the sums of treatments T_t.

The program computes :

Total sum of squares : $\sum y^2 - C.F.$ $\quad (C.F. = (\sum y)^2/n)$

Row S.S. : $\sum T_r^2/n - C.F.$

Column S.S. : $\sum T_c^2/n - C.F.$

Treatment S.S. : $\sum T_t^2/n - C.F.$

If F = Treat.M.S./Error M.S. is significant, the treatment means may be compared, using program STAT.08.

USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

STAT.07

Step Schritt Pas Passo	**Instructions** Operation Instructions Istruzioni	**Variables** Dateneingabe Données Dati	**Function(s)** Taste(n) Touche(s) Tasti	**Result** Resultat Résultat Risultato
1	Key in the program STAT.07, tracks 1 to 5			
2	Initialize		XEQ"ANVA.3"	
3	Enter : number of treatments (= rows = columns)	n	R/S	
4	Input the data of the first row in pairs : first nbr of treatment	n^o	R/S	
	then the résult	y_i	R/S	
5	At the end of the first row, call		B	
	Display : row sum T_r			ΣR
6	Correction routine			
	a - immediate . if necessary, finish to input the data of the pair, then call		E	
	input again the erroneous pair	n^o_E	R/S	
		y_E	R/S	
	then the correct one	n^o_C	R/S	
		y_C	R/S	
	b - delayed (but before calling B)		p.E	
	input : the number of the column	c	R/S	
	the erroneous pair	n^o_E	R/S	
		y_E	R/S	
	then the correct one	n^o_C	R/S	
		y_C	R/S	
7	Repeat step 4 and 5 for the other rows			
8	At the end of the last row,			
	Display of : column sums T_c			ΣC
	treatment sums T_t			ΣT
	treatment mean			MOY.T
	Display of the ANOVA			
9	If F (treatments) is significant, the treatment means can be compared using program STAT.08			
	For another set of data, call and return to step 3		A	

EXAMPLE 1 - Latin square

Subject	Treatment order				
	1	2	3	4	5
1	(1) 209	(4) 183	(2) 204	(3) 216	(5) 178
2	(4) 180	(3) 198	(5) 162	(2) 188	(1) 166
3	(2) 202	(5) 198	(3) 217	(1) 193	(4) 172
4	(3) 223	(1) 202	(4) 192	(5) 179	(2) 202
5	(5) 192	(2) 202	(1) 189	(4) 165	(3) 191

```
XEQ "ANVA3"
5,00      RUN

1,00      RUN
209,00    RUN
4,00      RUN
183,00    RUN
2,00      RUN
204,00    RUN
3,00      RUN
216,00    RUN
5,00      RUN
178,00    RUN
          XEQ B
ΣR=990,00

4,00      RUN
180,00    RUN
(error)   8,00 RUN
198,00    RUN
          XEQ E
8,00      RUN
198,00    RUN
3,00      RUN
198,00    RUN
5,00      RUN
162,00    RUN
2,00      RUN
188,00    RUN
1,00      RUN
166,00    RUN
          XEQ B
ΣR=894,00

2,00      RUN
202,00    RUN
5,00      RUN
198,00    RUN
3,00      RUN
217,00    RUN
1,00      RUN
193,00    RUN
4,00      RUN
172,00    RUN
          XEQ B
ΣR=982,00

3,00      RUN
(error)1.223,00 RUN
1,00      RUN
202,00    RUN
4,00      RUN
192,00    RUN
5,00      RUN
179,00    RUN
2,00      RUN
202,00    RUN
          XEQ e
1,00      RUN
3,00      RUN
1.223,00  RUN
3,00      RUN
223,00    RUN
          XEQ B
ΣR=998,00

5,00      RUN
192,00    RUN
2,00      RUN
202,00    RUN
1,00      RUN
189,00    RUN
4,00      RUN
165,00    RUN
3,00      RUN
191,00    RUN
          XEQ B
ΣR=939,00

ΣC.=1.006,00
ΣC.=983,00
ΣC.=964,00
ΣC.=941,00
ΣC.=909,00

ΣT.=959,00
MOY.T=191,80
ΣT.=998,00
MOY.T=199,60
ΣT.=1.045,00
MOY.T=209,00
ΣT.=892,00
MOY.T=178,40
ΣT.=909,00
MOY.T=181,80

ANVA
RANG.
D.L.=4,00
S.C.=1.524,64
C.M.=381,16
F=8,15
P=0,002

COL.
D.L.=4,00
S.C.=1.124,24
C.M.=281,06
F=6,01
P=0,007

TRAIT.
D.L.=4,00
S.C.=3.178,64
C.M.=794,66
F=16,99
P=1,860E-4

ERR.
D.L.=12,00
S.C.=561,12
C.M.=46,76

TOT.
D.L.=24,00
S.C.=6.388,64
```

PRINCIPLES OF STATISTICAL TESTS

The most frequent applications of statistics are to test some hypothesis. A statistical test is basically intended to evaluate the risk that the user is willing to take when accepting the hypothesis, or when rejecting that hypothesis and accepting an alternative one. The méthod is called Hypothesis testing.

Whatever the statistical test used, the procedure usually involves several steps :

1 - State the hypothesis.

The problem to be solved is defined by two hypotheses :

- the null hypothesis H_0, which is the hypothesis of no difference. For instance, if we want to compare the means of two groups and if a difference is found, we state that this difference is not real, but due to the sampling error.
- the alternative hypothesis, H_1, which will be accepted if H_0 is rejected. H_1 may be stated in two different ways :
  - H_{1a} : the research hypothesis simply states that the means of the two groups are different $\mu_1 \neq \mu_2$; this is a two-tailed test.
  - H_{1b} : the theory predicts the direction of the difference, if any. H_1 will be either $\mu_1 > \mu_2$ or $\mu_1 < \mu_2$; this is a one-tailed test.

2 - Choice of the statistical test.

We have many tests which can be used under various conditions. The criteria for choosing among several tests and the corresponding programs will be examined below.

3 - Choice of the significance level.

This is a limit which should be specified in advance of the data collection and which justifies the rejection of the null hypothesis. It is the risk of falsely rejecting H_0 when the null hypothesis is actually true. This error (Type I error) and the corresponding risk, commonly called α is usually set at the level P = 0,05.

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

```
01♦LBL "ANVA3"
02♦LBL A
03 CLRG
04 STOP
05 STO 20
06 13
07 X<=Y?
08 GTO 09
09 ADV
10♦LBL 01
11 STOP
12 2
13 *
14 28
15 +
16 STO 13
17 STOP
18 ST+ IND 25
19 7ISZ
20 ST+ IND 13
21 ΣREG 14
22 Σ+
23 GTO 01
24♦LBL B
25 RCL 15
26 ST+ 26
27 RCL 14
28 "ΣR"
29 XEQ 11
30 ST+ 27
31 X↑2
32 ST+ 28
33 CLΣ
34 0
35 STO 25
36 1
37 ST+ 29
38 RCL 20
39 RCL 29
40 X≠Y?
41 GTO 01
42 ADV
43♦LBL 02
44 RCL IND 25
45 "ΣC."
46 XEQ 11
47 X↑2
48 ST+ 21
49 7ISZ
50 RCL 20
51 RCL 25
52 X≠Y?
53 GTO 02
54 ADV
55 30
56 STO 25
57♦LBL 03
58 RCL IND 25
59 "ΣT."
60 XEQ 11
61 X↑2
62 ST+ 22
63 LASTX
64 RCL 20
65 /
66 "MOY.T"
67 XEQ 11
68 7ISZ
69 RCL 20
70 STO IND 25
71 7ISZ
72 RCL 20
73 2
74 *
75 30
76 +
77 RCL 25
78 X≠Y?
79 GTO 03
80 ADV
81 RCL 27
82 X↑2
83 RCL 20
84 X↑2
85 /
86 STO 01
87 RCL 26
88 RCL 01
89 -
90 STO 00
91 RCL 28
92 RCL 20
93 /
94 RCL 01
95 -
96 STO 02
97 RCL 21
98 RCL 20
99 /
100 RCL 01
101 -
102 STO 03
103 RCL 22
104 RCL 20
105 /
106 RCL 01
107 -
108 STO 04
109 RCL 00
110 RCL 02
111 RCL 03
112 RCL 04
113 +
114 +
115 -
116 STO 07
117 RCL 20
118 1
119 -
120 STO 09
121 RCL 20
122 2
123 -
124 *
125 STO 06
126 RCL 07
127 X<>Y
128 /
129 STO 05
130 "ANVA"
131 AVIEW
132 RCL 09
133 2
134 STO 25
135 "RANG."
136 AVIEW
137 XEQ 04
138 "COL."
139 AVIEW
140 XEQ 04
141 "TRAIT."
142 AVIEW
143 XEQ 04
144 "ERR."
145 AVIEW
146 RCL 06
147 "D.L."
148 XEQ 11
149 RCL 07
150 "S.C."
151 XEQ 11
152 RCL 05
153 "C.M."
154 XEQ 11
155 ADV
156 "TOT."
157 AVIEW
158 RCL 20
159 X↑2
160 1
161 -
162 "D.L."
163 XEQ 11
164 RCL 00
165 "S.C."
166 XEQ 11
167 RTN
168♦LBL 04
169 RCL 09
170 "D.L."
171 XEQ 11
172 RCL IND 25
173 "S.C."
174 XEQ 11
175 X<>Y
176 /
177 "C.M."
178 XEQ 11
179 RCL 05
180 /
181 STO 10
182 "F"
183 XEQ 11
184 XEQ 05
185 7ISZ
186 RTN
187♦LBL 05
188 2
189 9
190 /
191 STO 17
192 RCL 09
193 /
194 STO 14
195 RCL 17
196 RCL 06
197 /
198 STO 17
199 1
200 -
201 CHS
202 RCL 10
203 3
204 1/X
205 Y↑X
206 *
207 1
208 RCL 14
209 -
210 -
211 STO 15
212 RCL 17
213 RCL 10
214 2
215 3
216 /
217 Y↑X
218 *
219 RCL 14
220 +
221 SQRT
222 RCL 15
223 X<>Y
224 /
225 STO 16
226 X>0?
227 SF 02
228 ABS
229 1
230 RCL 16
231 ,196854
232 *
233 +
234 RCL 16
235 X↑2
236 ,115194
237 *
238 +
239 RCL 16
240 3
241 Y↑X
242 ,000344
243 *
244 +
245 RCL 16
246 4
247 Y↑X
248 ,019527
249 *
250 +
251 -4
252 Y↑X
253 2
254 /
255 CHS
256 1
257 +
258 FIX 3
259 FS?C 02
260 XEQ 06
261 "P"
262 XEQ 11
263 FIX 2
264 ADV
265 RTN
266♦LBL 06
267 1
268 X<>Y
269 -
270 RTN
271♦LBL 11
272 "├="
273 ARCL X
274 AVIEW
275 RTN
276♦LBL E
277 RCL 25
278 1
279 -
280 STO 25
281 STOP
282 2
283 *
284 28
285 +
```

Please use paper glue to attach listings. Adhesive tape may affect print!
Bitte Listings mit Papierleim einkleben. Klebefilme können Druck bleichen!

S.V.P. utilisez de la colle à papier pour fixer les listings. Les rubans adhesifs peuvent altérer l'impression!
Per favore usare la colla per fissare i listati. Il nastro adesivo puo alterare lo stampato!

```
286 STO 24
287 STOP
288 ST- IND 24
289 ST- IND 25
290 Σ-
291 GTO 01
292♦LBL e
293 STOP
294 1
295 -
296 STO 23
297 STOP
298 2
299 *
300 28
301 +
302 STO 24
303 STOP
304 ST- IND 23
305 ST- IND 24
306 Σ-
307 STOP
308 2
309 *
310 28
311 +
312 STO 24
313 STOP
314 ST+ IND 23
315 ST+ IND 24
316 Σ+
317 GTO 01
318 .END.
```

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

STAT.07

Registers
Datenspeicher
Registres de données
Registri

00	T_c Tot.S.S.	50	
	C.F.		
	Row S.S.		
	Column S.S.		
	Treat. S.S.		
05	Error M.S.	55	
	Error d.f.		
	Error S.S.		
	(n - 1)		
10		60	
	Storage for		
15	P(F) routine	65	
20	Σ n	70	
	ΣT_c^2		
	ΣT_t^2		
25		75	
	Σy^2		
	Σy		
	ΣT_r^2		
30	Sum treatm.$_i$	80	
	n_i		
	.		
	.		
	.		
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 055 Total Reg. _____

Eng ☐ Fix ☒ Sci ☐

Deg ☐ Rad ☐ Grad ☐

User Mode
On ☒
Off ☐

Purpose		Flags SET	Flags CLEAR
00			
01			
02	P(F) routine	X	
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
28	Decimal Point		
29	Digit Grouping		

Assignments
Tastenbelegung/Assignations/Assegnamenti

Function Funktion Fonction Funzione	Key Taste Touche Tasto	Function Funktion Fonction Funzione	Key Taste Touche Tasto

STAT.08

ANOVA - COMPARISONS AMONG MEANS

DESCRIPTION

After the initial significance test, a Model II ANOVA is completed by the estimation of the added variance components (See Prog.STAT.05). A Model I ANOVA is completed by examining the data in greater detail, testing which means are different from which other ones, or which groups of means are different from other such groups or from single means.

When these tests are planned before the experiment, and independently of the results, they are called "a priori" comparisons. These tests can be applied regardless of the results of the preliminary ANOVA. When the comparisons are decided after the experiments, being based on the results, they are called "a posteriori"tests, and they are performed only if the preliminary ANOVA is significant

1 - A priori tests

a - Subdivision of the treatment sums of squares and degrees of freedom into separate comparisons.

To compare k groups of any size n_i, take the sum of each group, square it, divide it by its sample size n_i and sum the k quotients thus obtained. From the sum of these quotients, substract a correction factor, which is the grand sum of all the groups in the comparison, squared and divided by the number of items in the grand sum. This S.S. has (k- 1) d.f. and the corresponding mean square is tested by an "F" test against the error mean square. If all the comparisons are independent, their S.S. and d.f. are additive.

b - Least significant difference - (L.S.D.)

This test is based on the "t" test : one computes

$$L.S.D. = t_{0,05} \sqrt{s^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

with s^2 = error mean square and $t_{0,05}$ = value of t for the number of d.f. of the ANOVA.

If a difference $(\bar{y}_1 - \bar{y}_2)$ is larger than the L.S.D., the two means differ significantly at the 0,05 significance level.

2 - A posteriori tests

a - Comparison of all the means to the same control

A frequent case is the separate comparison of all the treatment means $\bar{y}_i$ to the same control mean $\bar{y}_0$. This can be done with the Dunnett test. Each treatment mean is compared to $\bar{y}_0$: $(\bar{y}_0 - \bar{y}_i)$, and a value of "t" is computed as :

$$t = \frac{|\bar{y}_0 - \bar{y}_i|}{\sqrt{s^2\left(\frac{1}{n_0} + \frac{1}{n_i}\right)}}$$

If this calculated "t" is larger than a limit value "t'" found in the Dunnet table(*), which takes in account the number p of means $\bar{y}_i$ compared to the control, the difference is significant.

b - multiple comparisons

The overall comparison of all the means can be performed with the S.S. subdivision method described above, taking the number of d.f. of F as $(a - 1)$ and $a(n - 1)$; or with a method based on the studentized range, which has not been included in this program. (Duncan test, for instance) (**)

The program STAT.08 can be used after programs STAT.05, 06 or 07.

(*) C.W.DUNNETT - Biometrics 1964; 20; p.488

(**) J.PHILIPPE p.121

USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

STAT.08

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	When program 05, 06 or 07 has been			
	executed, clear the program		XEQ "CLP" " "	
2	Key in the program STAT.08, tracks			
	1 to 5			
	Least significant difference			
3	Initialize		A	
4	Input the number of the two groups			
	to be compared	n^o_1	R/S	
		n^o_2	R/S	
5	Display of : difference $\lvert\bar{y}_1 - \bar{y}_2\rvert$			DIFF
	least sign. diff.			PPSD
	result			SIGN. or N.S.
6	For another comparison, return to			
	step 4			
	Dunnett test			
7	Initialize		B	
	Display : number of groups compared			
	to the control			p
	d.f. of the ANOVA			D.L.
	The program asks for			t ?
	(value of Dunnett t)			
8	Input	$t_{0,05}$	R/S	
9	For all comparisons, display of :			
	$\lvert\bar{y}_0 - \bar{y}_i\rvert$			DIFF
	t calcul.			t
	result			SIGN. or N.S.
	Subdivision of treatment S.S.			
10	A priori test Initialize		C	
10'	A posteriori test Initialize		p.C	
11	Input the number of groups to be			
	compared	k	R/S	
12	Input the number(s) of the treat-			
	ment(s) of the first group	n^o.....	R/S	
13	Call		D	
14	Repeat steps 12 and 13 for each of			
	the other groups			
15	Display of : nbr of d.f.			D.L.
	sum of squares			S.C.
	mean square			C.M.
	F			F
	P(F)			P
16	For another comparison, return to			
	step 11			

EXAMPLE 1 - Program used after Program STAT.05

```
          3,00   RUN

        118,00   RUN
         85,00   RUN
         80,00   RUN
        102,00   RUN
         75,00   RUN
         65,00   RUN
         86,00   RUN
         73,00   RUN
               XEQ B

Σ=684,00
MOY.=85,50
VAR.=292,29

        120,00   RUN
         97,00   RUN
        103,00   RUN
        138,00   RUN
         96,00   RUN
        105,00   RUN
               XEQ B

Σ=659,00
MOY.=109,83
VAR.=264,57

        100,00   RUN
        128,00   RUN
        113,00   RUN
        134,00   RUN
               XEQ B

Σ=475,00
MOY.=118,75
VAR.=234,25

ANVA
TRAIT
D.L.=2,00
S.C.=3.650,42
C.M.=1.825,21
F=6,72
P=0,008

ERR
D.L.=15,00
S.C.=4.071,58
C.M.=271,44

TOT
D.L.=17,00
S.C.=7.722,00
```

L.S.D

```
                CLP ""
PACKING
                XEQ A
          1,00   RUN
          2,00   RUN
DIFF=24,33
PPDS=18,97
SIGN

          1,00   RUN
          3,00   RUN
DIFF=33,25
PPDS=21,51
SIGN

          2,00   RUN
          3,00   RUN
DIFF=8,92
PPDS=22,67
N.S.
```

Dunnett

```
                XEQ B
p=2,00
D.L.=15,00
t?
               2,44   run
DIFF=24,33
t=2,73
SIGN

DIFF=33,25
t=3,30
SIGN
```

Subdiv. S.S.

```
                          XEQ C
               2,00   RUN
               1,00   RUN
                      XEQ D
               2,00   RUN
               3,00   RUN
                      XEQ D
D.L.=1,00
S.C.=3.459,60
C.M.=3.459,60
F=12,75
P=0,003

               2,00   RUN
               2,00   RUN
                      XEQ D
               3,00   RUN
                      XEQ D
D.L.=1,00
S.C.=190,82
C.M.=190,82
F=0,70
P=0,420
```

EXAMPLE 2 - Program used after Program STAT.06

```
XEQ "ANVA2"
5,00    RUN
5,00    RUN

8,00    RUN
2,00    RUN
4,00    RUN
3,00    RUN
9       RUN
00      RUN
10,00   RUN
6,00    RUN
3,00    RUN
XEQ B

Σ.B=35,00

Σ.T=54,00
MOY.=10,80
Σ.T=31,00
MOY.=6,20
Σ.T=41,00
MOY.=8,20
Σ.T=33,00
MOY.=6,60
Σ.T=29,00
MOY.=5,80

ANVA
BLOC
D.L.=4,00
S.C.=49,84
C.M.=12,46
F.=2,30
P=0,103

TRAIT
D.L.=4,00
S.C.=83,84
C.M.=20,96
F.=3,87
P=0,022

ERR.
D.L.=16,00
S.C.=86,56
C.M.=5,41

TOT.
D.L.=24,00
S.C.=220,24
```

L.S.D.

```
                CLP ""
PACKING
                XEQ A
          1,00    RUN
          2,00    RUN
DIFF=4,60
PPDS=3,12
SIGN

          3,00    RUN
          4,00    RUN
DIFF=1,60
PPDS=3,12
N.S.
```

Dunnett

```
                XEQ B
p=4,00
D.L.=16,00
t?
          2,71    run
DIFF=4,60
t=3,13
SIGN

DIFF=2,60
t=1,77
N.S.

DIFF=4,20
t=2,86
SIGN

DIFF=5,00
t=3,40
SIGN
```

Subdiv. S.S.

```
                XEQ C
          2,00    RUN

          1,00    RUN
                XEQ D
          2,00    RUN
          3,00    RUN
          4,00    RUN
          5,00    RUN
                XEQ D
D.L.=1,00
S.C.=67,24
C.M.=67,24
F=12,43
P=0,003

          3,00    RUN

          1,00    RUN
                XEQ D
          2,00    RUN
          3,00    RUN
                XEQ D
          4,00    RUN
          5,00    RUN
                XEQ D
D.L.=2,00
S.C.=72,24
C.M.=36,12
F=6,68
P=0,008
```

EXAMPLE 3 - Program used after Program STAT.07

```
XEQ "ANVA3"
5,00    RUN

1,00    RUN
209,00  RUN
4,00    RUN
183,00  RUN
2,00    RUN
204,00  RUN
7       RUN

ΣT.=959,00
MOY.T=191,80
ΣT.=998,00
MOY.T=199,60
ΣT.=1.045,00
MOY.T=209,00
ΣT.=892,00
MOY.T=178,40
ΣT.=909,00
MOY.T=181,80

ANVA
RANG.
D.L.=4,00
S.C.=1.524,64
C.M.=381,16
F=8,15
P=0,002

COL.
D.L.=4,00
S.C.=1.124,24
C.M.=281,06
F=6,01
P=0,007

TRAIT.
D.L.=4,00
S.C.=3.178,64
C.M.=794,66
F=16,99
P=1,860E-4

ERR.
D.L.=12,00
S.C.=561,12
C.M.=46,76

TOT.
D.L.=24,00
S.C.=6.388,64
```

L.S.D.

```
                CLP ""
PACKING
                XEQ A
          1,00    RUN
          2,00    RUN
DIFF=7,80
PPDS=9,42
N.S.

          3,00    RUN
          5,00    RUN
DIFF=27,20
PPDS=9,42
SIGN
```

Dunnett

```
                XEQ B
p=4,00
D.L.=12,00
t?
          2,81    run
DIFF=7,80
t=1,80
N.S.

DIFF=17,20
t=3,98
SIGN

DIFF=13,40
t=3,10
SIGN

DIFF=10,00
t=2,31
N.S.
```

Subdiv. S.S.

```
                XEQ C
          2,00    RUN

          1,00    RUN
                XEQ D
          2,00    RUN
          3,00    RUN
          4,00    RUN
          5,00    RUN
                XEQ D
D.L.=1,00
S.C.=0,64
C.M.=0,64
F=0,01
P=0,410

          3,00    RUN

          1,00    RUN
                XEQ D
          2,00    RUN
          3,00    RUN
                XEQ D
          4,00    RUN
          5,00    RUN
                XEQ D
D.L.=2,00
S.C.=2.928,84
C.M.=1.464,42
F=31,32
P=7,559E-5
```

PROGRAM LISTING

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA


```
01♦LBL "STAT8"
02♦LBL A
03 CF 01
04 2,3777
05 RCL 06
06 /
07 E↑X
08 ,96
09 +
10 STO 22
11♦LBL 01
12 STOP
13 XEQ 02
14 STO 02
15 RCL IND 00
16 1/X
17 STO 03
18 STOP
19 XEQ 02
20 XEQ 03
21 RCL 22
22 *
23 "PPDS"
24 XEQ 11
25 RCL 04
26 XEQ 12
27 GTO 01
28♦LBL B
29 CF 01
30 RCL 20
31 1
32 -
33 SF 13
34 "P"
35 XEQ 11
36 CF 13
37 RCL 06
38 "D.L."
39 XEQ 11
40 SF 13
41 "T?"
42 PROMPT
43 STO 09
44 CF 13
45 RCL 20
46 2
47 *
48-29
49 +
50 1000
51 /
52 30
53 +
54 STO 00
55 RCL IND 00
56 ISG 00
57 RCL IND 00
58 /
59 STO 02
60 RCL IND 00
61 1/X
62 STO 03
63 ISG 00
64♦LBL 04
65 RCL IND 00
66 ISG 00
67 RCL IND 00
68 /
69 XEQ 03
70 RCL 04
71 X<>Y
72 /
73 SF 13
74 "T"
75 XEQ 11
76 CF 13
77 RCL 09
78 X<>Y
79 XEQ 12
80 ISG 00
81 GTO 04
82 RTN
83♦LBL 02
84 2
85 *
86 28
87 +
88 STO 00
89 RCL IND 00
90 STO 01
91 1
92 ST+ 00
93 RCL 01
94 RCL IND 00
95 /
96 RTN
97♦LBL 03
98 RCL 02
99 -
100 ABS
101 STO 04
102 "DIFF"
103 XEQ 11
104 RCL IND 00
105 1/X
106 RCL 03
107 +
108 RCL 05
109 *
110 SQRT
111 RTN
112♦LBL 12
113 X>Y?
114 GTO 05
115 "N.S."
116 AVIEW
117 GTO 06
118♦LBL 05
119 "SIGN"
120 AVIEW
121♦LBL 06
122 ADV
123 RTN
124♦LBL c
125 SF 01
126♦LBL C
127 0
128 STO 00
129 STO 01
130 STO 02
131 STO 03
132 STO 04
133 STOP
134 ADV
135 STO 08
136 STO 25
137♦LBL 07
138 STOP
139 2
140 *
141 28
142 +
143 STO 10
144 RCL IND 10
145 ST+ 00
146 ST+ 02
147 1
148 ST+ 10
149 RCL IND 10
150 ST+ 01
151 ST+ 03
152 GTO 07
153♦LBL D
154 RCL 00
155 X↑2
156 RCL 01
157 /
158 ST+ 04
159 0
160 STO 00
161 STO 01
162 7DSZ
163 GTO 07
164 FS? 01
165 GTO 08
166 RCL 08
167 1
168 -
169 STO 11
170 "D.L."
171 XEQ 11
172 GTO 09
173♦LBL 08
174 RCL 20
175 1
176 -
177 STO 11
178 "D.L."
179 XEQ 11
180♦LBL 09
181 RCL 02
182 X↑2
183 RCL 03
184 /
185 RCL 04
186 X<>Y
187 -
188 "S.C."
189 XEQ 11
190 RCL 08
191 1
192 -
193 /
194 "C.M."
195 XEQ 11
196 RCL 05
197 /
198 "F"
199 STO 12
200 XEQ 11
201 2
202 ENTER↑
203 9
204 /
205 STO 01
206 RCL 11
207 /
208 STO 03
209 RCL 01
210 RCL 06
211 /
212 STO 01
213 1
214 -
215 CHS
216 RCL 12
217 3
218 1/X
219 Y↑X
220 *
221 1
222 RCL 03
223 -
224 -
225 STO 07
226 RCL 01
227 RCL 12
228 2
229 ENTER↑
230 3
231 /
232 Y↑X
233 *
234 RCL 03
235 +
236 SQRT
237 RCL 07
238 X<>Y
239 /
240 STO 08
241 X>0?
242 SF 02
243 ABS
244 1
245 RCL 08
246 ,196854
247 *
248 +
249 RCL 08
250 X↑2
251 ,115194
252 *
253 +
254 RCL 08
255 3
256 Y↑X
257 ,000344
258 *
259 +
260 RCL 08
261 4
262 Y↑X
263 ,019527
264 *
265 +
266 -4
267 Y↑X
268 2
269 /
270 CHS
271 1
272 +
273 FIX 3
274 FS?C 02
275 XEQ 10
276 "P"
277 XEQ 11
278 FIX 2
279 ADV
280 GTO C
281♦LBL 10
282 1
283 X<>Y
284 -
285 RTN
```

Please use paper glue to attach listings. Adhesive tape may affect print!
Bitte Listings mit Papierleim einkleben. Klebefilme können Druck bleichen!

S.V.P. utilisez de la colle à papier pour fixer les listings. Les rubans adhésifs peuvent altérer l'impression
Per favore usare la colla per fissare i listati. Il nastro adesivo puo alterare lo stampato!

One may choose to set α at a lower level (i.e. 0,01), if one feels that the danger of falsely rejecting H_0 is important.
Another error which may be made is to accept H_0 when it is actually false; this is the type II error, and the corresponding risk is β ($1 - \beta$) is called the power of the test; this power increases with the size of the sample(s).

4 - Sampling distribution.
It is the distribution, under H_0, of the statistic chosen for the test (for instance: u, t, F, χ^2). The experimental value of this statistic is computed from the data, and the probability P corresponding to the calculated value, if H_0 is satisfied, is found in the proper table, or computed in the program.

5 - Decision.
If the probability associated with the observed value of the statistic is equal to or less than the previously determined significance level α, H_0 is considered as false and rejected, and H_1 is accepted. The difference is "significant". If the probality of the observed value is larger than H_0 cannot be rejected ; the difference is not statistically significant.

In the first case, we know that, when rejecting H_0, we accept a risk α to be wrong (for instance, 1 out of 20 if $\alpha = 0,05$). In the second case, not rejecting H_0 does not imply that H_0 is true; it may exist a small, but real différence δ , but the power of the test may not be sufficient to show it.

CHOICE OF THE TESTS

The choice between several tests is based on three criteria :

1 - the nature of the problem to be solved
It may be a comparison between dispersions or between means of two or more groups; the study of several factors,...

2 - the nature of the experimental data
The data may be classified in several types of measurements :

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

```
286♦LBL 11
287 "⊦="
288 ARCL X
289 AVIEW
290 RTN
291 .END.
```

STAT.08

REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers
Datenspeicher
Registres de données
Registri

00	$\bar{y}$	50	
	ΣT_i		
	$\bar{y}_1$		
	$1/n_1$		
	$\bar{y}_1 - \bar{y}_2$		
05	var.error	55	
	d.f.error		
	k		
	Dunnett t'		
10	nº treatm.	60	
15		65	
20		70	
	$t_{0,05}$		
25	counter	75	
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 055 Total Reg. _____ **User Mode**

Eng ☐ Fix ☒ Sci ☐ On ☒

Deg ☐ Rad ☐ Grad ☐ Off ☐

	Purpose (Bedeutung / Signification / Scopo)	SET	CLEAR
00	A posteriori test	X	
01			
02	P(F) routine	X	
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
28	Decimal Point		
29	Digit Grouping		

Assignments
Tastenbelegung/Assignations/Assegnamenti

Function (Funktion / Fonction / Funzione)	**Key** (Taste / Touche / Tasto)	**Function** (Funktion / Fonction / Funzione)	**Key** (Taste / Touche / Tasto)

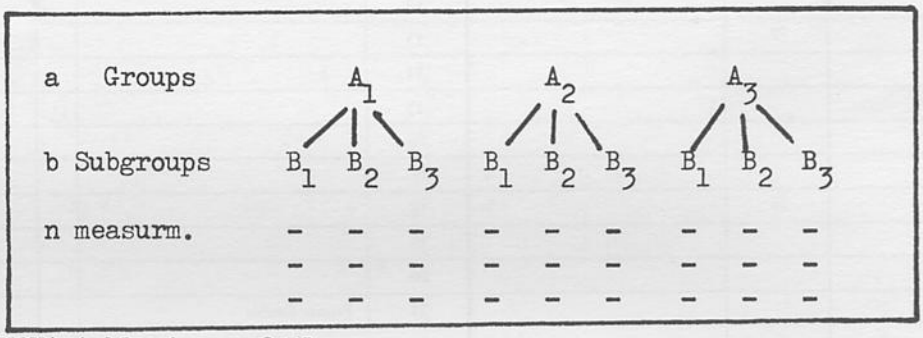
STAT.09

NESTED ANALYSIS OF VARIANCE

DESCRIPTION

In a nested (or hierarchic) ANOVA, each of the a groups is divided in b subgroups, the subordinate classification beeing nested within the higher level classification; n measurements are collected in each subgroup. This type of ANOVA may be used, for instance, to study an industrial process or an analytical method involving several steps.

The groups representing the subordinate level of classification (subgroups) must be randomly chosen. The higher level of classification may be Model II (random), giving a pure Model II ANOVA, or Model I (fixed) giving a Mixed Model ANOVA.



The ANOVA table is as follows :

Source of variation	Number of d.l.	Sum of squares	Mean square	F
Among groups	(a - 1)		s_g^2	
Among subgroups within groups	a(b - 1)		s_{sg}^2	
Within subgroups (error)	ab(n - 1)		s_e^2	
Total	abn - 1			

The existence of a variation among subgroups within groups is first tested by $F_1 = s_{sg}^2 / s_e^2$; then the significance of the variation among groups is tested by $F_2 = s_g^2 / s_{sg}^2$.

In a pure Model II ANOVA, one can estimate the variance among groups

STAT.09

σ^2_A, the variance of B within A $\sigma^2_{B(A)}$ and the variance of the error σ^2_E and the percent of total variation assignable to each source of variation. In a Mixed ANOVA, the different levels of A can be compared, using as error term s^2_{sg} when this term is significant, ar a pooled variance of s^2_{sg} and s^2_e when s^2_{sg} is not significant. The difference between means can be tested, using program STAT.08.

The data are entered by subgroups, starting with the first subgroup B_1 of the first group A_1; display of the subgroup totals T_b and of the group totals T_A. The program computes :

Total sum of squares : $\Sigma\ y^2$ - C.F. (1) C.F. = $(\Sigma\ y)^2/abn$

Group S.S. : $\Sigma\ T_a^2/bn$ - C.F. (2)

Subgroup S.S. : $\Sigma\ T_b^2/n$ - C.F. (3)

Among subgroups within groups S.S. = (3) - (2)

Within subgroups (error) S.S. = (1) - (2)

STAT.09

USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in program STAT.09, tracks 1 to 6			
2	Initialize		XEQ "ANVA.5"	
3	Enter : number of groups	a	R/S	
	number of subgroups	b	R/S	
	number of measurements par subgroup	n	R/S	
4	Input the data of the first subgroup of the first group	y_i.....	R/S	
5	Call		B	
	Display : subgroup total T_b			Σ B
6	Repeat steps 4 and 5 for the other subgroups of the first group			
7	At the end of the last subgroup, display : group total T_a			Σ A
8	Repeat steps 4 to 7 for the other groups			
9	Correction routine			
	Call		E	
	input the erroneous data	y_E	R/S	
	then the correct one	y_C	R/S	
10	At the end of the last group, display of the ANOVA			
	Model II ANOVA			
	Estimates of the several variances			
11	Call		C	
	Display of :			VAR.A & % VAR.B(A) & % VAR.E & %
12	For another set of data, call and return to step 3		A	
	Mixed Model ANOVA			
13	Call and go to Program STAT.08.		D	

EXAMPLE 1 - Nested ANOVA Model II (*)

```
          XEQ "ANVA5"
          4,00    RUN
          3,00    RUN
          2,00    RUN
                                  ΣB=5,43
          3,28    RUN
          3,09    RUN
                XEQ B
ΣB=6,37                           ΣB=7,18

          3,52    RUN
          3,48    RUN
                XEQ B
ΣB=7,00                           ΣB=5,10

          2,88    RUN             ΣA=17,71
          2,80    RUN
                XEQ B
ΣB=5,68

ΣA=19,05                          ΣB=7,65

          2,46    RUN
          2,44    RUN             (error)
                XEQ B
ΣB=4,90

          1,87    RUN
          1,92    RUN             ΣB=8,19
                XEQ B
ΣB=3,79

          2,19    RUN
          2,19    RUN             ΣB=6,62
                XEQ B
ΣB=4,38                           ΣA=22,46

ΣA=13,07

          2,77    RUN
          2,66    RUN
                XEQ B

          3,74    RUN
          3,44    RUN
                XEQ B

          2,55    RUN
          2,55    RUN
                XEQ B

          3,78    RUN
          3,87    RUN
                XEQ B

          4,07    RUN
         14,12    RUN
                XEQ E
         14,12    RUN
          4,12    RUN
                XEQ B

          3,31    RUN
          3,31    RUN
                XEQ B
```

```
ANVA
GROUP
D.L.=3,00
S.C.=7,56
C.M.=2,52
F=7,67
P=0,010

S/GROUP
D.L.=8,00
S.C.=2,63
C.M.=0,33
F=49,41
P=5,915E-6

ERR.
D.L.=12,00
S.C.=0,08
C.M.=0,01

TOT.
D.L.=23,00
S.C.=10,27
                                  XEQ C
VAR.A=0,37
VAR.A%=68,53
VAR.B(A)=0,16
VAR.B(A)%=30,22
VAR.ERR.=0,01
VAR.ERR.%=1,25
```

(*) SNEDECOR - p: 319

EXAMPLE 2 - Nested ANOVA Mixed Model

Same data used as if A were fixed treatments

```
                    Xt
ΣB=6,..                                          XEQ A
                                              1,00   RUN
ΣA=22,46                                      2,00   RUN
                                  DIFF=1,00
                                  PPDS=0,76
ANVA                              SIGN
GROUP
D.L.=3,00                                     2,00   RUN
S.C.=7,56                                     3,00   RUN
C.M.=2,52                         DIFF=0,77
F=7,67                            PPDS=0,76
P=0,010                           SIGN

S/GROUP                                       2,00   RUN
D.L.=8,00                                     4,00   RUN
S.C.=2,63                         DIFF=1,57
C.M.=0,33                         PPDS=0,76
F=49,41                           SIGN
P=5,915E-6
                                              XEQ C
ERR.                                       2,00   RUN
D.L.=12,00
S.C.=0,08                                  1,00   RUN
C.M.=0,01                                     XEQ D
                                           2,00   RUN
TOT.                                       3,00   RUN
D.L.=23,00                                 4,00   RUN
S.C.=10,27                                    XEQ D
                    XEQ D
                   CLP ""                 D.L.=1,00
                                          S.C.=0,21
PACKING             XEQ B                 C.M.=0,21
                                          F=0,65
p=3,00                                    P=0,450
D.L.=8,00
t?                                            2,00   RUN
              2,88   run
DIFF=1,00                                     2,00   RUN
t=3,01                                        3,00   RUN
SIGN                                             XEQ D
                                              4,00   RUN
DIFF=0,22                                        XEQ D
t=0,67
N.S.                              D.L.=1,00
                                  S.C.=5,55
DIFF=0,57                         C.M.=5,55
t=1,72                            F=16,89
N.S.                              P=0,004
```

PROGRAM LISTING

STAT.09

PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMMF
LISTATO DI PROGRAMMA

```
01♦LBL "ANVA5"
02♦LBL A
03 CLRG
04 STOP
05 STO 20
06 STOP
07 STO 21
08 STO 25
09 STOP
10 STO 22
11 30,054
12 STO 26
13 ADV
14♦LBL 01
15 STOP
16 ST+ 00
17 ΣREG 14
18 Σ+
19 GTO 01
20♦LBL B
21 RCL 00
22 "ΣB"
23 XEQ 11
24 ADV
25 ST+ 03
26 X↑2
27 RCL 22
28 /
29 ST+ 01
30 0
31 STO 00
32 7DSZ
33 GTO 01
34 RCL 21
35 STO 25
36 XEQ 02
37 RCL 03
38 "ΣA"
39 XEQ 11
40 ADV
41 X↑2
42 RCL 22
43 RCL 21
44 *
45 /
46 ST+ 02
47 0
48 STO 03
49 1
50 ST+ 04
51 RCL 04
52 RCL 20
53 X≠Y?
54 GTO 01
55 ADV
56 RCL 14
57 X↑2
58 RCL 20
59 RCL 21
60 RCL 22
61 *
62 *
63 /
64 STO 03
65 RCL 15
66 X<>Y
67 -
68 STO 04
69 RCL 02
70 RCL 03
71 -
72 STO 07
73 RCL 01
74 RCL 02
75 -
76 STO 08
77 RCL 15
78 RCL 01
79 -
80 STO 09
81 "ANVA"
82 AVIEW
83 "GRQUP"
84 AVIEW
85 RCL 20
86 1
87 -
88 "D.L."
89 XEQ 11
90 STO 00
91 RCL 07
92 "S.C."
93 XEQ 11
94 X<>Y
95 /
96 STO 07
97 "C.M."
98 XEQ 11
99 RCL 20
100 RCL 21
101 1
102 -
103 *
104 STO 01
105 STO 28
106 RCL 08
107 X<>Y
108 /
109 STO 24
110 RCL 07
111 X<>Y
112 /
113 STO 05
114 "F"
115 XEQ 11
116 XEQ 10
117 "S/GROUP"
118 AVIEW
119 RCL 01
120 STO 00
121 "D.L."
122 XEQ 11
123 RCL 08
124 "S.C."
125 XEQ 11
126 RCL 24
127 "C.M."
128 XEQ 11
129 RCL 20
130 RCL 21
131 RCL 22
132 1
133 -
134 *
135 *
136 STO 01
137 RCL 09
138 X<>Y
139 /
140 STO 06
141 RCL 24
142 X<>Y
143 /
144 "F"
145 XEQ 11
146 STO 05
147 XEQ 10
148 "ERR."
149 AVIEW
150 RCL 01
151 "D.L."
152 XEQ 11
153 RCL 09
154 "S.C."
155 XEQ 11
156 RCL 06
157 "C.M."
158 XEQ 11
159 ADV
160 "TOT."
161 AVIEW
162 RCL 20
163 RCL 21
164 RCL 22
165 *
166 *
167 1
168 -
169 "D.L."
170 XEQ 11
171 RCL 04
172 "S.C."
173 XEQ 11
174 RTN
175♦LBL 11
176 "⊦="
177 ARCL X
178 AVIEW
179 RTN
180♦LBL E
181 STOP
182 ST- 00
183 Σ-
184 GTO 01
185♦LBL 10
186 2
187 ENTER↑
188 9
189 /
190 STO 02
191 RCL 00
192 /
193 STO 13
194 RCL 02
195 RCL 01
196 /
197 STO 02
198 1
199 -
200 CHS
201 RCL 05
202 3
203 1/X
204 Y↑X
205 *
206 1
207 RCL 13
208 -
209 -
210 STO 14
211 RCL 02
212 RCL 05
213 2
214 ENTER↑
215 3
216 /
217 Y↑X
218 *
219 RCL 13
220 +
221 SQRT
222 RCL 14
223 X<>Y
224 /
225 STO 00
226 X>0?
227 SF 02
228 ABS
229 1
230 RCL 00
231 ,196654
232 *
233 +
234 RCL 00
235 X↑2
236 ,115194
237 *
238 +
239 RCL 00
240 3
241 Y↑X
242 ,000344
243 *
244 +
245 RCL 00
246 4
247 Y↑X
248 ,019527
249 *
250 +
251 -4
252 Y↑X
253 2
254 /
255 CHS
256 1
257 +
258 FIX 3
259 FS?C 02
260 XEQ 09
261 "P"
262 STO 27
263 XEQ 11
264 FIX 2
265 ADV
266 RTN
267♦LBL 09
268 1
269 X<>Y
270 -
271 RTN
272♦LBL 02
273 RCL 03
274 STO IND 26
275 ISG 26
276 RCL 21
277 RCL 22
278 *
279 STO IND 26
280 ISG 26
281 RTN
282♦LBL C
283 RCL 24
284 RCL 06
285 -
```

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

STAT.09

```
286 RCL 22
287 /
288 STO 01
289 RCL 07
290 RCL 24
291 -
292 RCL 22
293 /
294 RCL 21
295 /
296 STO 02
297 RCL 01
298 +
299 RCL 06
300 +
301 STO 03
302 RCL 02
303 "VAR.A"
304 XEQ 11
305 XEQ 05
306 "VAR.A%"
307 XEQ 11
308 RCL 01
309 "VAR.B(A)"
310 XEQ 11
311 XEQ 05
312 "VAR.B(A)%"
313 XEQ 11
314 RCL 06
315 "VAR.ERR."
316 XEQ 11
317 XEQ 05
318 "VAR.ERR.%"
319 XEQ 11
320 RTN
321*LBL 05
322 RCL 03
323 /
324 100
325 *
326 RTN
327*LBL D
328 ,05
329 RCL 27
330 X>Y?
331 GTO 03
332 RCL 24
333 STO 05
334 RCL 28
335 STO 06
336 GTO 04
337*LBL 03
338 RCL 09
339 RCL 08
340 +
341 RCL 01
342 RCL 28
343 +
344 STO 06
345 /
346 STO 05
347*LBL 04
348 RTN
349 .END.
```

REGISTERS, STATUS, FLAGS

STAT.09

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers
Datenspeicher
Registres de données
Registri

00	T_b ; d.f.1	50	
	a(b-1)		
	T_a^2/bn		
	~~T_a~~ S.S.		
	Total S.S.		
05	F	55	
	Error M.S.		
	Group S.S.		
	S/gr. S.S.		
	Error S.S.		
10		60	
	Statistic.		
15	stack	65	
20	a	70	
	b		
	n		
	S/gr. M.S.		
25		75	
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size 055 Total Reg. _____ **User Mode**

Eng ☐ Fix ☒ Sci ☐ On ☒

Deg ☐ Rad ☐ Grad ☐ Off ☐

Purpose (Bedeutung / Signification / Scopo)		Flags SET	Flags CLEAR
00			
01			
02	P(F) routine	X	
03			
04			
05			
06			
07			
08			
09			
10			
11	Audio execute		
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Printer Enable		
22	Number Input		
23	Alpha Input		
24	Range Ignore		
25	Error Ignore		
26	Audio Enable		
27	User Mode		
28	Decimal Point		
29	Digit Grouping		

Assignments
Tastenbelegung/Assignations/Assegnamenti

Function (Funktion / Fonction / Funzione)	Key (Taste / Touche / Tasto)	Function (Funktion / Fonction / Funzione)	Key (Taste / Touche / Tasto)

- nominal or classificatory variables

  the observations are distributed into two or more classes, and the variable is the frequencies in each category; they can also be expressed as ratios or percentages.

- ordinal or ranked variables

  the data are scores or measurements which can be ordered or ranked by increasing or decreasing values.

- measurement variables

  they may be continuous or discontinuous (discrete)

3 - the knowledge of the distribution

Each group of data is considered as a sample drawn at random from a population. Generally, the distribution of this population is not known, and the sample is too small to give an idea of this distribution, which must be assumed.

The different criteria determine three groups of tests :

1 - the variable is a measured quantity, normally distributed (or assumed normal). Parametric tests should be used.

2 - the data are scores, or measured variables known as non normal; the data are ranked and analysed with non parametric rank tests

3 - the data are frequencies; they are analysed with non parametric frequency tests.

It can be seen that the conditions of use of the parametric tests (normal distribution) are more stringent than the non parametric tests (sometimes called "distribution free"); but, for a given sample size, the parametric tests are also the more powerful.

A few suggestions for the choice of the appropriate test and the corresponding program are listed below :

A - the variable is measured and normally distributed :

1 - One sample

- mean and confidence interval Prog. STAT.01

- histogram and normality test 02

APPLIED STATISTICS I

MEANS AND CONFIDENCE INTERVAL
HISTOGRAM – NORMALITY TEST
TWO INDEPENDENT SAMPLES «F» AND «t» TESTS
TWO RELATED SAMPLES «t» TEST
SINGLE CLASSIFICATION ANOVA
COMPLETE BLOCK ANOVA
LATIN SQUARE ANOVA
COMPARISONS AMONG MEANS
NESTED ANOVA

00041-90246

Printed in U.S.A.

2 - Two samples

a - independent

. Comparison of variances : test "F"
. Comparison of means : test "t" STAT.03

b - related

. comparison of means : test "t" by difference 04

3 - More than two samples : Analysis of variance (ANOVA)

a - One factor

. single classification randomized ANOVA 05

. restrictions in design :
.. complete blocks 06
.. latin square 07

. comparison of means 08

b - Two factors

. hierarchic classification : nested ANOVA 09

. independent : two-way ANOVA 10

c - More than two factors

. three factors ANOVA (B nested and C crossed) 11

. three, four and five factors at two levels 12

4 - Relations between two factors

a - two random variables : correlation 13

b - one dependent variable : linear regression 14

c - one concomitant variable : analysis of covariance (ANCOVA) 15

B - The variable is measured, but not normally distributed, or is ordinal (scores); the data can be ranked 17

1 - Two samples

a - independent : Mann-Whitney U test

b - related : Wilcoxon signed-rank test

2 - More than two samples

a - independent : Kruskall-Wallis one-way ANOVA

b - related : Friedman two-way ANOVA

3 - Relationship between two variables : Spearman rank correlation coefficient

C - The variable is qualitative (frequencies)

1 - Tests of Goodness of fit : G test

2 - Contingency Tables

a - (2 x 2) Tables

. small samples : Fisher exact test

. large samples : Pearson X^2 test with correction of continuity

b - (r x c) Tables : G test

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The probability under H_0 of the several statistics used in the tests is computed by a subroutine, to avoid the consultation of tables. The following algorithms are used for this computation :

- Normal distribution

a - Ordinate at point u :

$$Z(u) = \frac{1}{\sqrt{2\pi}} e^{-u^2/2}$$

b - Probability

$$P(u) = 1 - 1/2 \, (1 + c_1 u + c_2 u^2 + c_3 u^3 + c_4 u^4)^{-4}$$

$c_1 = 0{,}196854$ $\quad c_3 = 0{,}000344$

$c_2 = 0{,}115194$ $\quad c_4 = 0{,}019527$

- Student "t" distribution

$$\theta = \tan^{-1}\left(\frac{|t|}{\sqrt{n'}}\right) \quad \text{(radians)} \qquad n' = \text{number of d.f.}$$

a - n' even

$$R = \sin\theta \left\{1 + \frac{1}{2}\cos^2\theta + \frac{1.3}{2.4}\cos^4\theta + \ldots\ldots + \frac{1.3.5\ldots\ldots(n'-3)}{2.4.6\ldots\ldots(n'-2)}\cos^{(n'-2)}\theta\right\}$$

b - n' odd

$n' = 1 \qquad R = 2\theta/\pi$

$n' > 1$

$$R = \frac{2\theta}{\pi} + \frac{2}{\pi}\cos\theta \left\{\sin\theta\left[1 + \frac{2}{3}\cos^2\theta + \ldots\ldots + \frac{2.4.6\ldots\ldots(n'-3)}{1.3.5\ldots\ldots(n'-2)}\cos^{(n'-3)}\theta\right]\right\}$$

Two-tailed test: $P(t) = 1 - R$

One-tailed test : $P(t) = \frac{(1 - R)}{2}$