DOCUMENT RESUME

ED 357 073 TM 019 852

AUTHOR McLean, James E.; Hebbler, Stephen W.
TITLE Generating Statistical Tables with Canned Statistical Software.
PUB DATE Apr 93
NOTE 18p.; Paper presented at the Annual Meeting of the American Educational Research Association (Atlanta, GA, April 12-16, 1993).
PUB TYPE Reports - Evaluative/Feasibility (142) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Chi Square; College Mathematics; *Computer Assisted Instruction; Computer Software; Higher Education; *Instructional Materials; Probability; *Statistical Data; *Tables (Data)
IDENTIFIERS F Test; *Software Tools; Statistical Analysis System; Statistical Packages; *Table Producing Language; T Test

ABSTRACT

A method of generating common statistical tables using canned statistical computer software is presented. This method allows instructors to provide statistical tables for their students, tailored to their needs. The four most common tables used in elementary college statistics courses are z (standard normal), t, F, and chi square. Specific "p" values for these common statistics are computed automatically by most statistical programs for the procedures that are being used. With a little formatting information, code can be written to cause the statistical software program to output tables. Procedures for producing these four tables using the Statistical Analysis System (SAS) software package are presented. These tables were downloaded into a word processor for this paper, and are included as Appendix B. Appendix A is the SAS code for generating the tables. (SLD)

GENERATING STATISTICAL TABLES

WITH

CANNED STATISTICAL SOFTWARE

James E. McLean and Stephen W. Hebbler

The University of Alabama

P. O. Box 870231
Tuscaloosa, AL 35487-0231
FAX: 205/348-6873
BITNET: JMCLEAN@UA1VM or SHEBBLER@UA1VM

Annual Meeting

American Educational Research Association

Atlanta, Georgia

April 1993

GENERATING STATISTICAL TABLES WITH CANNED STATISTICAL SOFTWARE

College statistics instructors often teach concepts and even entire courses from their notes rather than from a specific textbook. This gives them the option of selecting what they feel are the most important topics from a variety of texts and from more up to date journal articles. A problem with this approach is that the instructor still has to require a book in order for the students to have access to statistical tables or depend upon the statistical software they are using for p-values. The purpose of this paper is to present a method of generating common statistical tables using canned statistical computer software.

Instructors faced with the dilemma of providing statistical tables for their students have several options. As previously noted, they could require the purchase of a textbook even if only for the tables it contains. They could require the purchase of a tables reference. The problem with these approaches is overkill. Students would probably use only four or five of the many tables that would be included. Instructors could ignore the copyright laws and make copies of the tables the students would use. All of these approaches present ethical, legal, and/or moral dilemmas. This approach would be in keeping with recent suggestions made by Cohen (1990), Rosnow and Rosenthal (1989), and Thompson (1992, April). The dilemmas range from requiring students to purchase materials of which they would make only limited use to actually violating federal laws. A better option may be to depend on the p-values generated by statistical software. This paper presents a solution to the dilemmas and provides instructions with the option of using both p-values from the statistics software and having high quality tables available.

The four most common tables used in elementary statistics courses are z, t, F, and χ^2. Specific p-values for these common statistics are computed automatically by most statistical programs for the procedures that are being used. Sometimes, it is advantageous, especially during the introductory phase, to demonstrate how these values are found using tables. Most of the statistical software packages have built-in functions that compute these values. With a little formatting information, code can be written to cause the program to output statistical tables formatted similar to those in textbooks and reference books.

This paper presents procedures for producing several statistical tables using the SAS software package (SAS Institute, Inc.; 1989). Specifically, the SAS code and output is presented for producing z, t, F, and χ^2 tables. A member of the SAS Institute, Inc. staff originally shared with the authors code to produce an abbreviated normal curve area table. The code was expanded to include an entire standard normal table and the other three statistical tables. The SAS code for producing each of the tables can be found in Appendix A. The SAS code is also available free on a diskette from the authors. To get the code in ASCII code on four files, send a formatted disk to one of the authors. A similar technique could be used to produce other tables such as binomial, Tukey HSD (Studentized Range Statistic), and F_{max}. Similar code could be developed for producing the tables with most any statistical software package or with a programming language such as BASIC, FORTRAN, or C.

The tables can be used in the same way as the ones that appear in texts. They have been designed to provide the area under the curve beyond critical values. An instructor can generate a table and copy it for each student or the instructor can have each student

produce his or her own tables. In any event, the ability to generate statistical tables and reproduce them without copyright problems should make life easier for statistics instructors.

As previously noted, the SAS code for producing the z, t, F, and χ^2 tables can be found in Appendix A. Appendix B provides the tables produced by the code. It should be noted that the tables shown here were downloaded into a word processor for the purposes of this paper. WordPerfect for Windows 5.2 (WordPerfect Corporation, 1992) was used for producing the tables as well as this document. The authors grant full permission to reproduce the tables in this paper for noncommercial purposes as long as attribution is given.

References

Cohen, J. (1990). Things I have learned (so far). *American Psychologist, 45*(12), 1304-1312.

Rosnow, R. L., & Rosenthal, R. (1989). Statistical procedures and the justification of knowledge in psychological science. *American Psychologist, 44*(10), 1276-1284.

SAS Institute, Inc. (1989). *SAS Language and Procedures, Usage Version 6, First Edition.* Cary, NC: Author.

Thompson, B. (1992). *The use of statistical significance tests in research: Some criticisms and alternatives.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco, April 22.

WordPerfect Corporation. (1992). *WordPerfect for Windows, Version 5.2.* Orem, Utah: Author.

Appendix A

SAS Code for Generating Tables

SAS CODE FOR PRODUCING STANDARD NORMAL (Z) TABLE

```
OPTIONS LS=64 PS=66 NODATE NOTIME NONUMBER;
DATA ZTABLE;
   TITLE 'NORMAL CURVE AREA CHART';
   TITLE2
   'PROBABILITY OF A RANDOM VALUE OF Z = (X-M)/SIGMA';
   TITLE3
   'BEING GREATER THAN THE Z-VALUES IN THE MARGINS';
   FOOTNOTE 'GENERATED USING SAS';
   ARRAY ZDEC{10} ZDEC1-ZDEC10;
   ARRAY PVALUE{10} $5 PVALUE1-PVALUE10;
   DO J=0 TO 9;
      ZDEC{J+1}=J/100;
   END;
   DO Z=0 TO 3.5 BY .1;
      DO J=1 TO 10;
         PVALUE{J}=PUT(1-PROBNORM(Z+ZDEC{J}),5.4);
      END;
      OUTPUT;
   END;
   DROP J ZDEC1-ZDEC10;
   LABEL PVALUE1='.00' PVALUE2='.01' PVALUE3='.02' PVALUE4='.03'
         PVALUE5='.04' PVALUE6='.05' PVALUE7='.06' PVALUE8='.07'
         PVALUE9='.08' PVALUE10='.09';
PROC PRINT DATA=ZTABLE LABEL;
   VAR PVALUE1-PVALUE10;
   ID Z;
```

SAS CODE FOR PRODUCING T TABLE

```
OPTIONS LS=64 PS=60 NODATE NOTIME NONUMBER;
DATA TABLE;
   TITLE 'T-TABLE';
   TITLE2 'PROBABILITY OF A NUMERICALLY LARGER VALUE OF T';
   TITLE3 'FOR SELECTED ALPHAS AND DF';
   TITLE4 ' ';
   TITLE5 'ALPHA LEVEL';
   TITLE6 '
--------------------------------------------------------------';
   FOOTNOTE 'GENERATED USING SAS';
   ARRAY PVALUE{9} PVALUE1-PVALUE9;
   ARRAY TVALUE{9} $5 TVALUE1-TVALUE9;
   PVALUE1=.5;PVALUE2=.4;PVALUE3=.3;PVALUE4=.2;PVALUE5=.1;
   PVALUE6=.05;PVALUE7=.02;PVALUE8=.01;PVALUE9=.001;
   DO NDF=1 TO 30,40,60,120,3000;
      DO I=1 TO 9;
         TVALUE{I}=PUT(ABS(TINV(PVALUE{I}/2,NDF)),5.3);
      END;
      DF=PUT(NDF,3.);
      IF NDF=3000 THEN DF='INF';
      OUTPUT;
   END;
   DO I=1 TO 9;
      TVALUE{I}=' ';
   END;
   DF=' ';
   OUTPUT;

   TVALUE1='.5';TVALUE2='.4';TVALUE3='.3';TVALUE4='.2';
   TVALUE5='.1';TVALUE6='.05';TVALUE7='.02';TVALUE8='.01';
   TVALUE9='.001';
   OUTPUT;
   DROP I PVALUE1-PVALUE9;
   LABEL TVALUE1='0.5' TVALUE2='0.4' TVALUE3='0.3' TVALUE4='0.2'
         TVALUE5='0.1' TVALUE6='0.05' TVALUE7='0.02'
         TVALUE8='0.01' TVALUE9='0.001';
PROC PRINT DATA=TABLE LABEL;
   VAR TVALUE1-TVALUE9;
   ID DF;
```

SAS CODE FOR PRODUCING F TABLE

```
OPTIONS LS=132 PS=58 NODATE NOTIME NONUMBER;
DATA TABLE;
   TITLE 'F-TABLE';
   TITLE2 'PROBABILITY OF A NUMERICALLY LARGER VALUE OF F';
   TITLE4 'NUMERATOR DF';
   FOOTNOTE 'GENERATED USING SAS';
   ARRAY FVALUE{24} $4 FVALUE1-FVALUE24;
   ARRAY NDF{24} N1-N24 (1 2 3 4 5 6 7 8 9 10 11 12 15 20
                         24 30 40 50 60 100 120 200 500 5000);
   ARRAY DDF{22} D1-D22 (2 3 4 5 6 7 8 9 10 11 12 13
                         14 15 20 24 30 40 60 120 200 5000);
   DO D=1 TO 22;
      DO A=.90, .95, .99;
         DO N=1 TO 24;
            FVALUE{N}=PUT(ABS(FINV(A,NDF{N},DDF{D})),4.2);
         END;
      REF=DDF{D};
      DENOM=PUT(REF,3.);
      IF REF=5000 THEN DENOM='INF';
      IF A=.95 OR A=.99 THEN DENOM='   ';
      ALPHA=PUT(1-A,3.2);
      OUTPUT;
   END;
   DO I=1 TO 24;
      FVALUE{I}=' ';
   END;
   ALPHA=' ';  DENOM=' ';  OUTPUT;
   END;
   DO I=1 TO 24;
      FVALUE{I}=' ';
   END;
   ALPHA=' ';
   DENOM=' ';
   OUTPUT;
   LABEL FVALUE1='1' FVALUE2='2' FVALUE3='3' FVALUE4='4'
FVALUE5='5'
         FVALUE6='6' FVALUE7='7' FVALUE8='8' FVALUE9='9'
FVALUE10='10'
         FVALUE11='11' FVALUE12='12' FVALUE13='15' FVALUE14='20'
         FVALUE15='24' FVALUE16='30' FVALUE17='40' FVALUE18='50'
         FVALUE19='60' FVALUE20='100' FVALUE21='120'
FVALUE22='200'
         FVALUE23='500' FVALUE24='INF' DENOM='DENOM DF'
ALPHA='ALPHA';
PROC PRINT DATA=TABLE LABEL;
   VAR ALPHA FVALUE1-FVALUE24;
   ID DENOM;
```

SAS CODE FOR PRODUCING CHI SQUARE TABLE

```
OPTIONS LS=64 PS=60 NODATE NOTIME NONUMBER;
DATA TABLE;
  TITLE 'CHI-SQUARE VALUES';
  TITLE2 'ASSOCIATED WITH ALPHAS IN UPPER TAIL OF DISTRIBUTION';
  TITLE4 ' ';
  TITLE5 'ALPHA LEVEL';
  TITLE6 '
----------------------------------------------------';
  FOOTNOTE 'GENERATED USING SAS';
  ARRAY PVALUE{8} PVALUE1-PVALUE8;
  ARRAY CVALUE{8} $5 CVALUE1-CVALUE8;
  PVALUE1=.001;PVALUE2=.01;PVALUE3=.05;PVALUE4=.10;PVALUE5=.90;
  PVALUE6=.95;PVALUE7=.99;PVALUE8=.999;
  DO NDF=1 TO 30,40,60,120;
     DO I=1 TO 8;
        CVALUE{I}=PUT(ABS(CINV(PVALUE{I},NDF)),5.3);
     END;
     DF=PUT(NDF,3.);
     OUTPUT;
  END;
  DO I=1 TO 8;
     CVALUE{I}=' ';
  END;
  DF=' ';
  OUTPUT;

  CVALUE1='.001';CVALUE2='.01';CVALUE3='.05';CVALUE4='.10';
  CVALUE5='.90';CVALUE6='.95';CVALUE7='.99';CVALUE8='.999';
  OUTPUT;
  DROP I PVALUE1-PVALUE8;
  LABEL CVALUE1='.001' CVALUE2='.01' CVALUE3='.05' CVALUE4='.10'
        CVALUE5='.90' CVALUE6='.95' CVALUE7='.99'
        CVALUE8='.999';
PROC PRINT DATA=TABLE LABEL;
   VAR CVALUE1-CVALUE8;
   ID DF;
```

Appendix B

Statistical Tables

NORMAL CURVE AREA CHART
PROBABILITY OF A RANDOM VALUE OF Z = (X-M)/SIGMA BEING GREATER THAN THE Z-VALUES IN THE MARGINS

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641
0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
3.5	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002

GENERATED USING SAS

Source: McLean, J. E. & Hebbler, S. W. (1993, April). Generating statistical tables with canned statistical computer software. Paper presented at the Annual Meeting of the American Educational Research Association, Atlanta, GA.

T-TABLE
PROBABILITY OF A NUMERICALLY LARGER VALUE OF T FOR SELECTED ALPHAS AND DF

ALPHA LEVEL

DF	0.5	0.4	0.3	0.2	0.1	0.05	0.02	0.01	0.001
1	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	636.6
2	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	31.60
3	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	12.92
4	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	6.869
6	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.768
24	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.725
26	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.674
29	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.659
30	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.646
40	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.551
60	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	3.460
120	0.677	0.845	1.041	1.289	1.658	1.980	2.358	2.617	3.373
INF	0.675	0.842	1.037	1.282	1.645	1.961	2.328	2.577	3.294
	0.5	0.4	0.3	0.2	0.1	0.05	0.02	0.01	0.001

GENERATED USING SAS

Source: McLean, J. E. & Hebbler, S. W. (1993, April). Generating statistical tables with canned statistical computer software. Paper presented at the Annual Meeting of the American Educational Research Association, Atlanta, GA.

F-TABLE
PROBABILITY OF A NUMERICALLY LARGER VALUE OF F

NUMERATOR DF

DENOM DF	ALPHA	1	2	3	4	5	6	7	8	9	10	11	12	15	20	24	30	40	50	60	100	120	200	500	INF
2	.10	8.53	9.00	9.16	9.24	9.29	9.33	9.35	9.37	9.38	9.39	9.40	9.41	9.42	9.44	9.45	9.46	9.47	9.47	9.47	9.48	9.48	9.49	9.49	9.49
	.05	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
	.01	98.5	99.0	99.2	99.2	99.3	99.3	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5
3	.10	5.54	5.46	5.39	5.34	5.31	5.28	5.27	5.25	5.24	5.23	5.22	5.22	5.20	5.18	5.18	5.17	5.16	5.15	5.15	5.14	5.14	5.14	5.14	5.13
	.05	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.76	8.74	8.70	8.66	8.64	8.62	8.59	8.58	8.57	8.55	8.55	8.54	8.53	8.53
	.01	34.1	30.8	29.5	28.7	28.2	27.9	27.7	27.5	27.3	27.2	27.1	27.1	26.9	26.7	26.6	26.5	26.4	26.4	26.3	26.2	26.2	26.2	26.1	26.1
4	.10	4.54	4.32	4.19	4.11	4.05	4.01	3.98	3.95	3.94	3.92	3.91	3.90	3.87	3.84	3.83	3.82	3.80	3.80	3.79	3.78	3.78	3.77	3.76	3.76
	.05	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.94	5.91	5.86	5.80	5.77	5.75	5.72	5.70	5.69	5.66	5.66	5.65	5.64	5.63
	.01	21.2	18.0	16.7	16.0	15.5	15.2	15.0	14.8	14.7	14.5	14.5	14.4	14.2	14.0	13.9	13.8	13.7	13.7	13.7	13.6	13.6	13.5	13.5	13.5
5	.10	4.06	3.78	3.62	3.52	3.45	3.40	3.37	3.34	3.32	3.30	3.28	3.27	3.24	3.21	3.19	3.17	3.16	3.15	3.14	3.13	3.12	3.12	3.11	3.11
	.05	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.70	4.68	4.62	4.56	4.53	4.50	4.46	4.44	4.43	4.41	4.40	4.39	4.37	4.37
	.01	16.3	13.3	12.1	11.4	11.0	10.7	10.5	10.3	10.2	10.1	9.96	9.89	9.72	9.55	9.47	9.38	9.29	9.24	9.20	9.13	9.11	9.08	9.04	9.02
6	.10	3.78	3.46	3.29	3.18	3.11	3.05	3.01	2.98	2.96	2.94	2.92	2.90	2.87	2.84	2.82	2.80	2.78	2.77	2.76	2.75	2.74	2.73	2.73	2.72
	.05	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.03	4.00	3.94	3.87	3.84	3.81	3.77	3.75	3.74	3.71	3.70	3.69	3.68	3.67
	.01	13.7	10.9	9.78	9.15	8.75	8.47	8.26	8.10	7.98	7.87	7.79	7.72	7.56	7.40	7.31	7.23	7.14	7.09	7.06	6.99	6.97	6.93	6.90	6.88
7	.10	3.59	3.26	3.07	2.96	2.88	2.83	2.78	2.75	2.72	2.70	2.68	2.67	2.63	2.59	2.58	2.56	2.54	2.52	2.51	2.50	2.49	2.48	2.48	2.47
	.05	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.60	3.57	3.51	3.44	3.41	3.38	3.34	3.32	3.30	3.27	3.27	3.25	3.24	3.23
	.01	12.2	9.55	8.45	7.85	7.46	7.19	6.99	6.84	6.72	6.62	6.54	6.47	6.31	6.16	6.07	5.99	5.91	5.86	5.82	5.75	5.74	5.70	5.67	5.65
8	.10	3.46	3.11	2.92	2.81	2.73	2.67	2.62	2.59	2.56	2.54	2.52	2.50	2.46	2.42	2.40	2.38	2.36	2.35	2.34	2.32	2.32	2.31	2.30	2.29
	.05	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.31	3.28	3.22	3.15	3.12	3.08	3.04	3.02	3.01	2.97	2.97	2.95	2.94	2.93
	.01	11.3	8.65	7.59	7.01	6.63	6.37	6.18	6.03	5.91	5.81	5.73	5.67	5.52	5.36	5.28	5.20	5.12	5.07	5.03	4.96	4.95	4.91	4.88	4.86
9	.10	3.36	3.01	2.81	2.69	2.61	2.55	2.51	2.47	2.44	2.42	2.40	2.38	2.34	2.30	2.28	2.25	2.23	2.22	2.21	2.19	2.18	2.17	2.17	2.16
	.05	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.10	3.07	3.01	2.94	2.90	2.86	2.83	2.80	2.79	2.76	2.75	2.73	2.72	2.71
	.01	10.6	8.02	6.99	6.42	6.06	5.80	5.61	5.47	5.35	5.26	5.18	5.11	4.96	4.81	4.73	4.65	4.57	4.52	4.48	4.41	4.40	4.36	4.33	4.31
10	.10	3.29	2.92	2.73	2.61	2.52	2.46	2.41	2.38	2.35	2.32	2.30	2.28	2.24	2.20	2.18	2.16	2.13	2.12	2.11	2.09	2.08	2.07	2.06	2.06
	.05	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.94	2.91	2.85	2.77	2.74	2.70	2.66	2.64	2.62	2.59	2.58	2.56	2.55	2.54
	.01	10.0	7.56	6.55	5.99	5.64	5.39	5.20	5.06	4.94	4.85	4.77	4.71	4.56	4.41	4.33	4.25	4.17	4.12	4.08	4.01	4.00	3.96	3.93	3.91
11	.10	3.23	2.86	2.66	2.54	2.45	2.39	2.34	2.30	2.27	2.25	2.23	2.21	2.17	2.12	2.10	2.08	2.05	2.04	2.03	2.01	2.00	1.99	1.98	1.97
	.05	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.82	2.79	2.72	2.65	2.61	2.57	2.53	2.51	2.49	2.46	2.45	2.43	2.42	2.41
	.01	9.65	7.21	6.22	5.67	5.32	5.07	4.89	4.74	4.63	4.54	4.46	4.40	4.25	4.10	4.02	3.94	3.86	3.81	3.78	3.71	3.69	3.66	3.62	3.60
12	.10	3.18	2.81	2.61	2.48	2.39	2.33	2.28	2.24	2.21	2.19	2.17	2.15	2.10	2.06	2.04	2.01	1.99	1.97	1.96	1.94	1.93	1.92	1.91	1.90
	.05	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.72	2.69	2.62	2.54	2.51	2.47	2.43	2.40	2.38	2.35	2.34	2.32	2.31	2.30
	.01	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.50	4.39	4.30	4.22	4.16	4.01	3.86	3.78	3.70	3.62	3.57	3.54	3.47	3.45	3.41	3.38	3.36
13	.10	3.14	2.76	2.56	2.43	2.35	2.28	2.23	2.20	2.16	2.14	2.12	2.10	2.05	2.01	1.98	1.96	1.93	1.92	1.90	1.88	1.88	1.86	1.85	1.85
	.05	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.63	2.60	2.53	2.46	2.42	2.38	2.34	2.31	2.30	2.26	2.25	2.23	2.22	2.21
	.01	9.07	6.70	5.74	5.21	4.86	4.62	4.44	4.30	4.19	4.10	4.02	3.96	3.82	3.66	3.59	3.51	3.43	3.38	3.34	3.27	3.25	3.22	3.19	3.17

GENERATED USING SAS

F-TABLE
PROBABILITY OF A NUMERICALLY LARGER VALUE OF F

DENOM DF	ALPHA	NUMERATOR DF 1	2	3	4	5	6	7	8	9	10	11	12	15	20	24	30	40	50	60	100	120	200	500	INF
14	.10	3.10	2.73	2.52	2.39	2.31	2.24	2.19	2.15	2.12	2.10	2.07	2.05	2.01	1.96	1.94	1.91	1.89	1.87	1.86	1.83	1.83	1.82	1.80	1.80
	.05	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.57	2.53	2.46	2.39	2.35	2.31	2.27	2.24	2.22	2.19	2.18	2.16	2.14	2.13
	.01	8.86	6.51	5.56	5.04	4.69	4.46	4.28	4.14	4.03	3.94	3.86	3.80	3.66	3.51	3.43	3.35	3.27	3.22	3.18	3.11	3.09	3.06	3.03	3.01
15	.10	3.07	2.70	2.49	2.36	2.27	2.21	2.16	2.12	2.09	2.06	2.04	2.02	1.97	1.92	1.90	1.87	1.85	1.83	1.82	1.79	1.79	1.77	1.76	1.76
	.05	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.51	2.48	2.40	2.33	2.29	2.25	2.20	2.18	2.16	2.12	2.11	2.10	2.08	2.07
	.01	8.68	6.36	5.42	4.89	4.56	4.32	4.14	4.00	3.89	3.80	3.73	3.67	3.52	3.37	3.29	3.21	3.13	3.08	3.05	2.98	2.96	2.92	2.89	2.87
20	.10	2.97	2.59	2.38	2.25	2.16	2.09	2.04	2.00	1.96	1.94	1.91	1.89	1.84	1.79	1.77	1.74	1.71	1.69	1.68	1.65	1.64	1.63	1.62	1.61
	.05	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.31	2.28	2.20	2.12	2.08	2.04	1.99	1.97	1.95	1.91	1.90	1.88	1.86	1.84
	.01	8.10	5.85	4.94	4.43	4.10	3.87	3.70	3.56	3.46	3.37	3.29	3.23	3.09	2.94	2.86	2.78	2.69	2.64	2.61	2.54	2.52	2.48	2.44	2.42
24	.10	2.93	2.54	2.33	2.19	2.10	2.04	1.98	1.94	1.91	1.88	1.85	1.83	1.78	1.73	1.70	1.67	1.64	1.62	1.61	1.58	1.57	1.56	1.54	1.53
	.05	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.22	2.18	2.11	2.03	1.98	1.94	1.89	1.86	1.84	1.80	1.79	1.77	1.75	1.73
	.01	7.82	5.61	4.72	4.22	3.90	3.67	3.50	3.36	3.26	3.17	3.09	3.03	2.89	2.74	2.66	2.58	2.49	2.44	2.40	2.33	2.31	2.27	2.24	2.21
30	.10	2.88	2.49	2.28	2.14	2.05	1.98	1.93	1.88	1.85	1.82	1.79	1.77	1.72	1.67	1.64	1.61	1.57	1.55	1.54	1.51	1.50	1.48	1.47	1.46
	.05	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.13	2.09	2.01	1.93	1.89	1.84	1.79	1.76	1.74	1.70	1.68	1.66	1.64	1.62
	.01	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	3.07	2.98	2.91	2.84	2.70	2.55	2.47	2.39	2.30	2.25	2.21	2.13	2.11	2.07	2.03	2.01
40	.10	2.84	2.44	2.23	2.09	2.00	1.93	1.87	1.83	1.79	1.76	1.74	1.71	1.66	1.61	1.57	1.54	1.51	1.48	1.47	1.43	1.42	1.41	1.39	1.38
	.05	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.04	2.00	1.92	1.84	1.79	1.74	1.69	1.66	1.64	1.59	1.58	1.55	1.53	1.51
	.01	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99	2.89	2.80	2.73	2.66	2.52	2.37	2.29	2.20	2.11	2.06	2.02	1.94	1.92	1.87	1.83	1.81
60	.10	2.79	2.39	2.18	2.04	1.95	1.87	1.82	1.77	1.74	1.71	1.68	1.66	1.60	1.54	1.51	1.48	1.44	1.41	1.40	1.36	1.35	1.33	1.31	1.29
	.05	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.95	1.92	1.84	1.75	1.70	1.65	1.59	1.56	1.53	1.48	1.47	1.44	1.41	1.39
	.01	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82	2.72	2.63	2.56	2.50	2.35	2.20	2.12	2.03	1.94	1.88	1.84	1.75	1.73	1.68	1.63	1.60
120	.10	2.75	2.35	2.13	1.99	1.90	1.82	1.77	1.72	1.68	1.65	1.63	1.60	1.55	1.48	1.45	1.41	1.37	1.34	1.32	1.28	1.26	1.24	1.21	1.19
	.05	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.87	1.83	1.75	1.66	1.61	1.55	1.50	1.46	1.43	1.37	1.35	1.32	1.28	1.26
	.01	6.85	4.79	3.95	3.48	3.17	2.96	2.79	2.66	2.56	2.47	2.40	2.34	2.19	2.03	1.95	1.86	1.76	1.70	1.66	1.56	1.53	1.48	1.42	1.38
200	.10	2.73	2.33	2.11	1.97	1.88	1.80	1.75	1.70	1.66	1.63	1.60	1.58	1.52	1.46	1.42	1.38	1.34	1.31	1.29	1.24	1.23	1.20	1.17	1.15
	.05	3.89	3.04	2.65	2.42	2.26	2.14	2.06	1.98	1.93	1.88	1.84	1.80	1.72	1.62	1.57	1.52	1.46	1.41	1.39	1.32	1.30	1.26	1.22	1.19
	.01	6.76	4.71	3.88	3.41	3.11	2.89	2.73	2.60	2.50	2.41	2.34	2.27	2.13	1.97	1.89	1.79	1.69	1.63	1.58	1.48	1.45	1.39	1.33	1.28
INF	.10	2.71	2.30	2.08	1.95	1.85	1.78	1.72	1.67	1.63	1.60	1.57	1.55	1.49	1.42	1.38	1.34	1.30	1.27	1.24	1.19	1.17	1.13	1.09	1.04
	.05	3.84	3.00	2.61	2.37	2.22	2.10	2.01	1.94	1.88	1.83	1.79	1.75	1.67	1.57	1.52	1.46	1.40	1.35	1.32	1.25	1.22	1.17	1.11	1.05
	.01	6.64	4.61	3.79	3.32	3.02	2.81	2.64	2.51	2.41	2.32	2.25	2.19	2.04	1.88	1.79	1.70	1.60	1.53	1.48	1.36	1.33	1.25	1.16	1.07

GENERATED USING SAS

Source: McLean, J. E. & Hebbler, S. W. (1993, April). Generating statistical tables with canned statistical computer software. Paper presented at the Annual Meeting of the American Educational Research Association, Atlanta, GA.

CHI-SQUARE VALUES

ASSOCIATED WITH ALPHAS IN UPPER TAIL OF DISTRIBUTION

	ALPHA LEVEL							
DF	0.999	0.99	0.95	0.90	C.10	0.05	0.01	0.001
1	0.000	0.000	0.004	0.016	2.706	3.841	6.635	10.83
2	0.002	0.020	0.103	0.211	4.605	5.991	9.210	13.82
3	0.024	0.115	0.352	0.584	6.251	7.815	11.34	16.27
4	0.091	0.297	0.711	1.064	7.779	9.488	13.28	18.47
5	0.210	0.554	1.145	1.610	9.236	11.07	15.09	20.52
6	0.381	0.872	1.635	2.204	10.64	12.59	16.81	22.46
7	0.598	1.239	2.167	2.833	12.02	14.07	18.48	24.32
8	0.857	1.646	2.733	3.490	13.36	15.51	20.09	26.12
9	1.152	2.088	3.325	4.168	14.68	16.92	21.67	27.88
10	1.479	2.558	3.940	4.865	15.99	18.31	23.21	29.59
11	1.834	3.053	4.575	5.578	17.28	19.68	24.72	31.26
12	2.214	3.571	5.226	6.304	18.55	21.03	26.22	32.91
13	2.617	4.107	5.892	7.042	19.81	22.36	27.69	34.53
14	3.041	4.660	6.571	7.790	21.06	23.68	29.14	36.12
15	3.483	5.229	7.261	8.547	22.31	25.00	30.58	37.70
16	3.942	5.812	7.962	9.312	23.54	26.30	32.00	39.25
17	4.416	6.408	8.672	10.09	24.77	27.59	33.41	40.79
18	4.905	7.015	9.390	10.86	25.99	28.87	34.81	42.31
19	5.407	7.633	10.12	11.65	27.20	30.14	36.19	43.82
20	5.921	8.260	10.85	12.44	28.41	31.41	37.57	45.31
21	6.447	8.897	11.59	13.24	29.62	32.67	38.93	46.80
22	6.983	9.542	12.34	14.04	30.81	33.92	40.29	48.27
23	7.529	10.20	13.09	14.85	32.01	35.17	41.64	49.73
24	8.085	10.86	13.85	15.66	33.20	36.42	42.98	51.18
25	8.649	11.52	14.61	16.47	34.38	37.65	44.31	52.62
26	9.222	12.20	15.38	17.29	35.56	38.89	45.64	54.05
27	9.803	12.88	16.15	18.11	36.74	40.11	46.96	55.48
28	10.39	13.56	16.93	18.94	37.92	41.34	48.28	56.89
29	10.99	14.26	17.71	19.77	39.09	42.56	49.59	58.30
30	11.59	14.95	18.49	20.60	40.26	43.77	50.89	59.70
40	17.92	22.16	26.51	29.05	51.81	55.76	63.69	73.40
60	31.74	37.48	43.19	46.46	74.40	79.08	88.38	99.61
120	77.76	86.92	95.70	100.6	140.2	146.6	159.0	173.6
	0.999	0.99	0.95	0.90	0.10	0.05	0.01	0.001

GENERATED USING SAS

Source: McLean, J. E. & Hebbler, S. W. (1993, April). Generating statistical tables with canned statistical computer software. Paper presented at the Annual Meeting of the American Educational Research Association, Atlanta, GA.