INSTRUCTOR'S EDITION

STATISTICS

TUTORIAL AND COMPUTATIONAL SOFTWARE FOR THE BEHAVIORAL SCIENCES

TUTOR

SECOND EDITION

JOSEPH D. ALLEN
DAVID J. PITTENGER

Statistics Tutor:

Tutorial and Computational Software for the Behavioral Sciences

Second Edition

Instructor's Edition

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To Daphne, Denise, Rebbecca, and Alexander, who continue to tolerate our extended sessions in front of the computer to produce this tutorial.

PREFACE

We wrote the first edition of *Statistics Tutor* during a time when computers were making their first inroads to higher education. At that time, the typical computer had, by today's standards, limited speed, memory, and graphics quality. Our first experiments in computer assisted education began with the Commodore 64, a computer company that has since lost its fortune and is now a dim memory in the short history of the personal computer. When we started writing *Statistics Tutor*, most computers had limited internal memory (e.g., 640K RAM), crude graphics, and slow clock speeds. We were, however, able to achieve our goal — to prepare a collection of interactive programs to help students understand the foundations of statistical principles and concepts.

As we finish the second edition of *Statistics Tutor*, we find that computers and their uses have changed dramatically. What was once inconceivable is now common place. The contemporary computer has an operating speed and capacity that are far superior to the 8088 chip we once thought was magnificent. At the same time, computers are now a more commonly accepted component of the educational process. Many students now come to college with their own computers and with a fair degree of sophistication in using complex software. Thus, part of our motivation for revising *Statistics Tutor* had been to make use of the enhanced capacity of the current generation of computers. For example, the new programs make use of the higher quality graphics that were not available a mere six years ago. Similarly, we have added features that were too time-consuming for the older and slower generation of computers.

We have also revised the programs to reflect changes in how behavioral researcher teach and use statistics. For example, we have revised many of the tutorials to further emphasis the importance of power in the discussion of statistical tests. In addition, we revised the interaction tutorial dramatically to demonstrate the use of residuals to explain the meaning of a significant interaction.

Although the advances in computer technology have afforded many technical changes, we saw no need to revise the philosophy that underlies our design of educational software. We believe that the computer meets its goal as a teaching machine when it responds to the student rather than requiring the student to react to the computer. To us, the computer should be a virtual laboratory in which the inquisitive student can easily ask questions and receive a quick answer. In other words, we want to provide a statistics laboratory experience that will allow students to better understand fundamental statistical

concepts. We see the computer as useful tool in statistics because it can quickly and accurately model many phenomena for the students. Consequently, the student can attend more to the underlying principles than to the tedium of generating random samples and conducting many intermediate calculations.

We have chosen to write programs that model a complex statistical principle and allow students to vary one or more of the critical factors associated with that principle. For example, in the General Linear Model tutorial, the student can systematically vary the effect size, sample size, alpha level, directionality of the hypotheses, and the type of research design. As we guide students through the tutorial, we show them how these factors interact to influence the power of a statistical test.

The following is brief description of the 10 tutorials.

1. **Descriptive Statistics and Exploratory Data Analysis**
   This program provides a brief introduction to exploratory data analytic tools such as the stem-and-leaf plot and the box-and-whisker graph. The tutorial also reviews basic descriptive statistics, which include measures of central tendency, measures of dispersion, and measures of shape. The program allows the user to work with data saved on the disk or randomly generated data drawn from predefined populations.

2. **Binomial Distribution**
   This program allows students to experiment with the quincunx, a device first used by Sir Francis Galton, to demonstrate the fundamental principles of sampling distributions. In this version of the demonstration, the user is able to change the number of points in the quincunx as well as the probability of the event (e.g., $p < .5$ or $p > .5$). This flexibility allows the user to experiment with the quincunx and to begin to learn the foundation of the sampling theory and sampling distributions.

3. **Correlation and Regression**
   This program introduces the student to the concepts of the Pearson Product Moment Correlation Coefficient and the least squares regression. The tutorial emphasizes the interpretation of the correlation and regression statistics. In addition, we examine the effects of restricting the range on the size of the correlation. The program allows the user to work with data saved on the disk or randomly generated data drawn from predefined populations.

4. **The Normal Curve**
   The tutorial demonstrates the use and importance of the normal curve for statistics. Students learn how to convert raw scores into *z*-scores and then use the normal distribution to make specific inferences from the data.

5. **Central Limit Theorem**
   This program illustrates the central limit theorem by allowing students to generate samples from diverse populations. The tutorial introduces the students to the concept of the sampling distribution and the predictions of the central limit theorem. The program allows the student to sample from a diverse array of populations to illustrate the robust quality of the theorem.

6. The General Linear Additive Model

This tutorial introduces the student to the concepts of the general linear additive model, hypothesis testing, and statistical power. The computer allows the student to conduct Monte Carlo trials for a simple *t*-test. The student may use either an independent groups or a correlated groups design. As in all the tutorials, the student can vary all the significant parameters in the model. Consequently, the student can learn about the interrelation among effect size, sample size, alpha level, research design, and power.

7. The *t*-test and Power

This tutorial presents a more formal exploration of statistical power using the *t*-test as the format of understanding power. The program allows the student to manipulate sample size, sampling error, effect size, alpha level, type of test, and research design to determine the power of the test.

8. The One-Way ANOVA

We provide a graphical introduction to the concepts of between-groups and within-groups variance and the *F*-ratio within this tutorial. The computer allows the user to vary systematically the means and sampling error of four groups. As these variables change, the computer provides a rich graphic display of the between-groups and within-groups variation. This tutorial also introduces students to the *F*-ratio and *post hoc* tests.

9. The Two-Way ANOVA and Interaction

This program allows students to explore the factorial ANOVA and the concept of interaction. The computer presents the user with a two-factor experiment. The user can change each factor from a 2-level to a 3-level variable. The user can then vary the means of the independent treatment cells. The computer automatically revises the marginal means and the ANOVA summary table. Therefore, the user can create any combination of main effects and interaction effects. With a click of the mouse button, the user can convert the sample means to residuals.

10. Sampling Distributions

The last program is a collection of routines that allow the student to examine many of the more familiar sampling distributions including 1) the normal distribution, 2) Student's *t*-distribution, 3) Fisher's *F*-distribution, 4) the Poisson Distribution, and 5) the Chi-Square distribution. For each distribution, the user can vary the necessary parameter(s) that affect the shape of the distribution. The computer then prepares a graph of the distribution. As the user moves the mouse through the distribution, the computer reports the probability of the observed value.

We believe that this highly interactive software, presented in conjunction with the workbook and supportive teaching, will help novice and advanced students of statistics master these important statistical principles.

ACKNOWLEDGMENTS

Many people have influenced the direction and development of *Statistics Tutor*. Our first debt of gratitude is owed to Ronald Simpson and the staff at the Office of Instructional Design at the University of Georgia, who gave us our first grants to write tutorial programs on a Commodore computer. Using these programs in classroom lectures and demonstrations, we discovered which techniques are most and least useful in conveying the concepts of statistics.

The tutorial sections of *Statistics Tutor* have been used to supplement lectures in countless undergraduate statistics and experimental design courses at the University of Georgia; at the University of Guelph, where J. D. Allen was a visiting professor during the 1987-88 academic year; and, more recently, at Marietta College, where D. J. Pittenger accepted the chairmanship of the Psychology Department. We are indebted to the candid and critical comments made by students in these classes. Along the way, we also consulted with some of the statistics experts at these universities. Drs. Milton Hodge and Gary Lautenschlager at the University of Georgia and Drs. John Hundleby and J. J. Hubert at the University of Guelph figure prominently among those ensuring the authenticity of the statistical concepts presented in this package.

During the development of the program software and documentation, a number of colleagues test-drove the programs and provided us with invaluable suggestions for correction and improvement. We wish to extend to each of them our gratitude for their insights and assistance. They are:

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Special thanks go to Jun Yu who converted the programs to their current Windows version. We are greatly impressed with his professionalism, quick and accurate work, and willingness to go well beyond the call of duty. This project would have been realized without his expertise.

Finally, much credit is due our editor, Ms. Ellen Schatz, who helped us develop the tutorials into a complete learning package.

Joseph D. Allen

David J. Pittenger

John Wiley & Sons, Inc
Welcome to Statistics Tutor!

by

Joseph D. Allen &
David J. Pittenger

Minimum System Requirements:

Windows 95/98/NT

- IBM compatible computer with Pentium 100 MHz processor or higher
- Double-speed CD-ROM drive
- VGA color monitor, 256 colors
- 16 MB RAM
- 2.5 MB hard drive space

Installing the Statistics Tutor CD-ROM:

Windows 95/98/NT

1) Insert CD into CD-ROM drive
2) From Windows desktop, select Run from the Start Menu
3) Type in D:\SETUP.EXE if 'D' is your CD-ROM drive. If not, substitute proper drive designation.
4) Click 'OK' or press the Enter Key.
5) Follow the instructions on the screen. Statistics Tutor will normally create and then install into the C:\Program Files\Statistics Tutor folder. If you wish to install the program in another location, then make the appropriate drive and directory changes during the initial installation routine.

Getting Started:

1) Click on "Start"
2) Select the Programs Menu and Click on the 'Statistics Tutor' icon.
3) To exit the program, either click on the Exit Statistics Tutor button in the Main Menu, or click on the 'Close' button (the 'X') at the top right of your screen.

Uninstalling Statistics Tutor:

1) Click on 'My Computer' icon on your desktop
2) Click on 'Control Panel' within My Computer module
3) Click on 'Add/Remove' option within the control panel
4) Scroll down the window of program listings until you find 'Statistics Tutor'
5) Highlight 'Statistics Tutor' by clicking on it and then click on the Add/Remove panel.
6) You will be presented with the caution message, 'Are you sure you want to completely remove Statistics Tutor and all of its contents'. Click the 'Yes' button, and the program is uninstalled.

For Technical Support:

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