> Mastering Teacher Leadership

This case is about a multistage communication study of teachers by Wittenberg University's Department of Education to determine the viability of starting a Master of Education program for Ohio-certified teachers working within school districts serving a five-county area. www.wittenberg.edu

> Match Wits with Jason on Sampling Theory

This case presents a debate between researcher Jason Henry and a loan officer of a bank on the appropriate sample size for a study required by the bank of a small business applying for a loan to expand operations. The student is asked to anticipate sampling decisions and explain the rationale for each sampling decision.

> McDonald's Tests Catfish Sandwich

This case describes the test marketing for McDonald's catfish sandwich in the southeastern United States. It asks students to assume they are the new product development team and to assess the research design described.

> Medical Laboratories

A hospital faces a 20 percent price increase from its outside testing lab based on rising costs of testing and diminishing profits. The student is asked to analyze data from 16 different medical labs and make a recommendation about the financial health of each lab, supporting or refuting the basis of the proposed price increase.

> NCRCC: Teeing Up a New Strategic Direction

The NCR Country Club started out as a benefit for thousands of National Cash Register employees. By the late 1990s, those employees were aging rapidly and the core membership needed to be increased. NCRCC offers two golf courses. One is an award-winning, championship-hosting course on the PGA tour. But the club wasn't attracting new members, especially younger families. This case is about a membership study done as part of a larger management initiative to evaluate several strategic directions the club might take to expand its membership. www.ncrcountryclub.com

> NetConversions Influences Kelley Blue Book

Kelley Blue Book (KBB) is one of the most visited automotive sites on the Web. Visitors flock there to estimate the price of a car they might buy or sell. KBB needed to enhance its site's performance for advertisers, who had become a major source of revenue as sales of the printed *Kelley Blue Book* had declined. NetConversions is one of the new Web analytic services to evaluate Web site performance. This case reveals how Web sites are evaluated so that new design elements can be developed and tested. **www.netconversions.com; www.kelleybluebook.com**

> Open Doors: Extending Hospitality to Travelers with Disabilities

Eric Lipp started the Open Doors Organization (ODO) to help travelers with disabilities. In order to get the attention of the travel and hospitality industries, and to effect changes desired by people with disabilities, ODO undertook a major research project to estimate the expenditures of persons with disabilities and the accommodations that would be necessary to get them to travel more. Harris Interactive was chosen to field the multimethod survey. This case describes the methodology and the effects of the first round of a multiphase study. **www.opendoorsnfp.org**

> Overdue Bills

This case is about testing a hypothesis related to collection on open accounts. The firm profiled is Quick Stab Collection Agency (QSCA). It is contemplating a change in its company slogan, or tagline. It needs research to substantiate the anticipated claim. The agency's accountant suspects that the amount of time to collect an account is determined by the size of the delinquent account and draws a sample of accounts to find out if he is correct. The student is asked to recommend a slogan to the marketing department based on an analysis of the results.

> Performance Evaluations

Ann, an independent consultant in human resource issues, is evaluating the quality and veracity of the employee evaluation procedure used by XYZ Co. She draws a sample of 144 employee evaluations using 10 variables. The pool of evaluations contains 125 employees who remain employed with the company and 19 who left or were terminated. The student is asked to evaluate the data and to report to Ann what she should report to XYZ Co.

> Ramada Demonstrates Its *Personal Best*™

This case describes syndicated research in the hospitality industry that revealed trends in customer satisfaction and Ramada's proprietary research leading to the development of the *Personal Best*™ employee hiring, training, and motivation program. **www.ramada.com**

> Retailers Unhappy with Displays from Manufacturers

This case asks the student to design an experiment to test a new display design for Raid, following the release of survey results by a retail advisory board that revealed 60 percent dissatisfaction with current tracking systems provided to retailers by manufacturers.

> Rubbergate

This case reveals data drawn during the House banking scandal dubbed "Rubbergate". The data presented evaluate the banking practices of a sample of U.S. congresspersons. The student is asked to analyze the data and draw conclusions about whether a lobbying firm should exclude certain congresspersons from its efforts, based on their banking record.

> Starbucks, Bank One, and Visa Launch Starbucks Card Duetto™ Visa

In the very mature financial services industry, it is rare for a new financial product to garner much attention, let alone be named one of *BusinessWeek*'s outstanding products of the year. But what started as a way for Starbucks to add value to its existing Starbucks Card program developed into a financial product that many other institutions are interested in exploring. This case reveals the research that was done to develop this new payment option for Starbucks customers. (Video duration: 11 minutes)
www.starbucks.com; www.bankone.com; www.visa.com

> State Farm: Dangerous Intersections

State Farm, the nation's largest auto insurer, distributed a list of the 10 most dangerous intersections in the United States based on crashes resulting in claims by its policyholders. What started as a study to reduce risk turned into an ongoing study that directs a major public relations effort: State Farm provides funds for communities to further research their dangerous intersections and initiate improvements based on the research. This case tells how the State Farm Dangerous Intersections initiative got started and how it is done.
www.statefarm.com

> Sturgel Division

This case profiles Martha, the manager of the Information Services division of Sturgel. She is trying to determine whether a survey of users should be conducted annually to assess the quality of service provided to

the other divisions of the company, with the results used to make policy and procedural changes in her division. If a survey is deemed appropriate, the student is asked to design the survey.

> The Brazing Operation

A manufacturer is evaluating the metallurgical structure and corrosion resistance of its vacuum brazing process. It extracts a sample from its statistical process control data to determine if its goals are being met. The student is asked to analyze the data and make a recommendation.

> The Catalyst for Women in Financial Services

Smith Barney (now Solomon Smith Barney) was ordered by the court, in settling the landmark sexual harassment case, to evaluate the climate for personal development and advancement through promotion not only in Smith Barney but, as a comparative, in other financial services firms. The case describes the methodology used to sample both men's and women's beliefs and attitudes, as well as reveals some of the basic findings.

> T-Shirt Designs

This case focuses on research done by Julio, a student who wants to raise money to pay off a portion of his student loans. The case provides a survey and data set and then asks the student to prepare a report recommending one of two prototype T-shirts Julio is considering.

> USTA: Come Out Swinging

The United States Tennis Association funded one of the most aggressive surveys ever undertaken about a single sport in order to revitalize tennis in the minds of consumers. The survey results were supplemented with qualitative research by Vigilante, a specialist in urban communication campaigns. What resulted was a full-scale marketing initiative involving the establishment of Tennis Welcome Centers and the Come Out Swinging advertising, merchandising, and public relations campaigns. This case reveals the research and how the marketing initiative developed. (Video duration: 11 minutes) **www.usta.com; www.vigilantenyc.com**

> Violence on TV

KTDS TV faces a rising number of viewer and advertiser complaints about program violence. The general manager is concerned about whether the complaints represent a sample of true viewer opinion or are a result

of the vocal disparaging of TV violence by a recent political candidate. Students are asked to evaluate the results of a public opinion poll and report to KTDS's general manager.

> Volkswagen's Beetle

This video case profiles the history of the original Beetle in the U.S. market from its introduction in 1949 to its demise in 1979 and then follows the initial two years of the New Beetle's rebirth, 1998 and 1999. The Beetle became a symbol of the 1960s rebelliousness, but it lost the love of a generation when it stressed engineering over style and low-cost operation, two factors that baby boomers considered crucial in the 1970s. By 1974, the Beetle had lost ground to its aggressive Japanese rivals for the value segment of the U.S. automobile market. In 1998, when the Beetle was reintroduced in the United States, it surpassed all sales estimates. The second year it doubled its sales. Historically, the Beetle is the world's best-selling car, having sold in more countries than any other automobile, with 21 million cars sold in its lifetime. (Video duration: 16 minutes) **www.vw.com**

> Waste Paper

This case depicts the results of a statistical process control procedure that measures waste of a printer, which produces small books for a variety of customers. The student is asked if the "waste factor" used to estimate bids for printing jobs should be the same for all sizes of four-color books or should vary based on size of book in number of pages.

> Xerox Abuses

This case profiles an experiment between the offices of the third and tenth floor of a firm in their use of their floor's Xerox copier. Each tenth-floor worker has been assigned a personal copy card; the third-floor workers have not. The case asks the student to determine whether issuing personal copy cards will effectively lower copier usage if implemented companywide.

> Yahoo!: *Consumer Direct* Marries Purchase Metrics to Banner Ads

As little as two years ago, many advertising pundits were bemoaning the inevitable demise of the banner ad on the Internet. But maybe they were too quick to judge. This case reveals how Yahoo!, in combination with ACNielsen's *Homescan®*, has developed a methodology *(Consumer Direct)* to evaluate the true effectiveness of banner ads, from ad exposure to shopping cart. It also reveals the role Dynamic Logic played in conducting postexposure ad evaluation. **www.yahoo.com; www.acnielsen.com; www.dynamiclogic.com**

>appendices

>appendixa

Focus Group Discussion Guide*

Background

What if your firm manufactures cleansing products in multiple forms—deodorant bar, beauty bar, cream body wash, gel body wash—and your customers are not using the best form for their skin types and activity levels? You might use exploratory focus groups to determine what drivers motivate customers to select the *form* they choose. Given the dramatic growth in this market, you want to hear from women aged 16 to 50 and also from men aged 16 to 25. Also, you need to understand their trade-offs when choosing a specific form.

  You turn to a research specialist to conduct focus groups in three cities representative of the category market. Prior to meeting the six groups (two groups in each city; two consisting only of teens), researchers ask each participant to prepare two visual collages using pictures cut from magazines. One collage is to reflect the participant's perceptions and experiences with each form (regardless of personal use experience). A second collage is to depict a month in the participant's life. The Intro and Forms segments of the discussion guide below reference these creative exercises.

Personal Cleansing Form Drivers Atlanta, Seattle, Phoenix

INTRO (15 min)

  A. ALL ABOUT ME—name, family info, work, play, activities, interests. SHOW LIFE IN THE MONTH COLLAGE
  B. AT SOME POINT ASK: How often shower / bathe?
       Use fragrances / perfume? How often?
       Use scented or unscented deodorant, lotions, etc?

FORMS (60 min)

  A. LISTED ON EASEL "DEODORANT BAR, BEAUTY BAR, CREAM BODY WASH, GEL BODY WASH" Here are
   the different forms of soaps available that we want to learn about.
   How many have ever used _____ ? Still using or moved on / rejected?
  B. EASEL RESPONSES (BE SURE PICTURES ARE LABELED) Show and describe your picture collage (from home-
   work), as you tell what you like / not, what **associate w/** _____ form.

     What else **like**? / **why use**?
     What **not like** about _____ ? Why not using (more often)?
     How compare to other forms—advantages / disadvantages?
     What **wish for** this form . . . what would make it **better / perfect** for you?

How / why **begin** to use? Specifically, what **remember** about _____ form then?

How find out about it? (ads, TV commercial, friends) What details remember about the ad—what show, who in it?

REPEAT FOR ALL FORMS

C. LINE UP THE FORMS—When you think about these different forms, are they **basically the same**—just a different form or do you think of these as different products with **different results**? Describe.

D. EXPLAIN CHART—Line these attributes up in the order you think is **best to worst for each of the attributes** listed on the paper.

CLEANLINESS / SKIN CARE / GERM KILL / DEODORANCY / LATHER / SCENT / VALUE

Why put in this order? What experience / notice with this form for (_attribute above_)?

What about the form makes that difference?

How much do you care about (_attributes above_)? Why / not? Affect whether you'd buy it?

E. SHOW EXAMPLES OF BRANDS WITH BOTH BAR AND BODY WASH—

Oil of Olay / Dove / Lever 2000 / Dial

So to summarize with some specific brands, whether you have tried or not, what would you **expect to be the difference,** if any, when using the bar of _____ brand vs. the body wash?

What difference, if any, in how they make you feel emotionally after bathing with the bar vs. body wash?

BRANDS (30 min)

A. Now let's focus on different brands. Write your favorite on your name card.

LINE UP EXAMPLES OF THOSE COMMONLY USED.

B. How many of you have used _____ ? How often / long ago?

Why **use / choose** (at store)? What like (better) about _____ .

Why NOT use (more often)?

C. How many have **tried Oil of Olay / Dove / Lever 2000 / Dial**? Why / not (more recently)?

What associate with (brand above)? What stand for? What makes it different / unique vs. other brands?

SUMMARY (15 min)

A. There are 3 basic considerations when choosing a soap—**brand, form, price.** Put them in order of what matters most, 2nd, 3rd. For example, you go to the store to buy, and your usual form isn't available in your usual brand, etc. What would you buy?

MAKE A CHART OF RESPONSES

B. Now think about 3 benefits we've discussed—**skin care, scent, cleanliness.** Put these in order of importance. Describe order.

Why is _____ more important than _____ ?

(MISC—TIME PERMITTING)

C. What do you see / notice in the store when shopping this aisle? New things? Switch around?

ADULTS—How many of you buy soap for other family members? Who? How do you decide which form / brand to choose for your husband / teen?

D. TEENS ONLY—Let's talk a bit more about how you learn about new types brands or versions of soaps. Where have you seen ads?

(Mall / locker room / Channel 1/ dressing rooms / etc.)

What do you remember about it? What show / say / what was the main idea?

What think of celebrity endorsements?

CONCLUSION

>appendixb

Nonparametric Significance Tests

This appendix contains additional nonparametric tests of hypotheses to augment those described in Chapter 18 (see Exhibit 18-7).

One-Sample Test

Kolmogorov-Smirnov Test

This test is appropriate when the data are at least ordinal and the research situation calls for a comparison of an observed sample distribution with a theoretical distribution. Under these conditions, the Kolmogorov-Smirnov (KS) one-sample test is more powerful than the χ^2 test and can be used for small samples when the χ^2 test cannot. The KS is a test of goodness of fit in which we specify the *cumulative* frequency distribution that would occur under the theoretical distribution and compare that with the observed cumulative frequency distribution. The theoretical distribution represents our expectations under H_0. We determine the point of greatest divergence between the observed and theoretical distributions and identify this value as D (maximum deviation). From a table of critical values for D, we determine whether such a large divergence is likely on the basis of random sampling variations from the theoretical distribution. The value for D is calculated as follows:

$$D = maximum \: |F_0(X) - F_T(X)|$$

in which

$F_0(X)$ = the observed cumulative frequency distribution of a random sample of n observations. Where X is any possible score, $F_0(X) = k/n$, where k = the number of observations equal to or less than X.

$F_T(X)$ = the theoretical frequency distribution under H_0.

We illustrate the KS test, with an analysis of the results of the dining club study, in terms of various class levels. Take an equal number of interviews from each class, but secure unequal numbers of people interested in joining. Assume class levels are ordinal measurements. The testing process is as follows (see accompanying table):

	Freshman	Sophomore	Junior	Senior	Graduate
Number in each class	5	9	11	16	19
$F_0(X)$	5/60	14/60	25/60	41/60	60/60
$F_T(X)$	12/60	24/60	36/60	48/60	60/60
$|F_0(X) - F_T(X)|$	7/60	10/60	11/60	7/60	0

$D = 11/60 = .183;$

$n = 60$

1. *Null hypothesis.*

    H_0: There is no difference among student classes as to their intention of joining the dining club.

    H_A: There is a difference among students in various classes as to their intention of joining the dining club.

2. *Statistical test.* Choose the KS one-sample test because the data are ordinal measures and we are interested in comparing an observed distribution with a theoretical one.

3. *Significance level.* $\alpha = .05$, $n = 60$.

4. *Calculated value.* $D = $ maximum $|F_0(X) - F_T(X)|$.

5. *Critical test value.* We enter the table of critical values of D in the KS one-sample test (see Appendix C, Exhibit C-5) and learn that with $\alpha = 05$, the critical value for D is

$$D = \frac{1.36}{\sqrt{60}} = .175$$

6. *Interpretation.* The calculated value is greater than the critical value, indicating we should reject the null hypothesis.

Two-Samples Tests

Sign Test

The sign test is used with matched pairs when the only information is the identification of the pair member that is larger or smaller or has more or less of some characteristic. Under H_0, one would expect the number of cases in which $X_A > X_B$ to equal the number of pairs in which $X_B > X_A$. All ties are dropped from the analysis, and n is adjusted to allow for these eliminated pairs. This test is based on the binomial expansion and has a good power efficiency for small samples.

Wilcoxon Matched-Pairs Test

When you can determine both *direction* and *magnitude* of difference between carefully matched pairs, use the Wilcoxon matched-pairs test. This test has excellent efficiency and can be more powerful than the t-test in cases where the latter is not particularly appropriate. The mechanics of calculation are also quite simple. Find the difference score (d_i) between each pair of values, and rank-order the differences from smallest to largest without regard to sign. The actual signs of each difference are then added to the rank values, and the test statistic T is calculated. T is the sum of the ranks with the less frequent sign. Typical of such research situations might be a study where husband and wife are matched, where twins are used, where a given subject is used in a before-after study, or where the outputs of two similar machines are compared.

Two types of ties may occur with this test. When two observations are equal, the d score becomes zero, and we drop this pair of observations from the calculation. When two or more pairs have the same d value, we average their rank positions. For example, if two pairs have a rank score of 1, we assign the rank of 1.5 to each and rank the next largest difference as third. When $n < 25$, use the table of critical values (see Appendix C, Exhibit C-4). When $n > 25$, the sampling distribution of T is approximately normal with

$$\text{Mean} = \mu_T = \frac{n(n + 1)}{4}$$

$$\text{Standard deviation} = \sigma_T \sqrt{\frac{n(n + 1)(2n + 1)}{24}}$$

The formula for the test is

$$z = \frac{T - \mu_T}{\sigma_T}$$

Suppose you conduct an experiment on the effect of brand name on quality perception. Ten subjects are recruited and asked to taste and compare two samples of a product, one identified as a well-known drink and the other as a new product being tested. In truth, however, the samples are identical. The subjects are then asked to rate the two samples on a set of scale items judged to be ordinal. Test these results for significance by the usual procedure.

1. *Null hypothesis.*

   H_0: There is no difference between the perceived qualities of the two samples.

   H_A: There is a difference in the perceived quality of the two samples.

2. *Statistical test.* The Wilcoxon matched-pairs test is used because the study is of related samples in which the differences can be ranked in magnitude.

3. *Significance level.* $\alpha = .05$, with $n = 10$ pairs of comparisons minus any pairs with a d of zero.

4. *Calculated value.* T equals the sum of the ranks with the less frequent sign. Assume we secure the following results:

Pair	Branded	Unbranded	d_i	Rank of d_i	Rank with Less Frequent Sign
1	52	48	4	4	
2	37	32	5	5.5*	
3	50	52	-2	-2	2
4	45	32	13	9	
5	56	59	-3	-3	3
6	51	50	1	1	
7	40	29	11	8	
8	59	54	5	5.5*	
9	38	38	0	—	
10	40	32	8	7	$T = 5$

*There are two types of tie situations. We drop out the pair with the type of tie shown by pair 9. Pairs 2 and 8 have a tie in rank of difference. In this case, we average the ranks and assign the average value to each.

5. *Critical test value.* Enter the table of critical values of T with $n = 9$ (see Appendix C, Exhibit C-4) and find that the critical value with $\alpha = .05$ is 6. Note that with this test, the calculated value must be smaller than the critical value to reject the null hypothesis.

6. *Interpretation.* Since the calculated value is less than the critical value, reject the null hypothesis.

Kolmogorov-Smirnov Two-Samples Test

When a researcher has two independent samples of ordinal data, the Kolmogorov-Smirnov (KS) two-samples test is useful. Like the one-sample test, this two-samples test is concerned with the agreement between two cumulative distributions, but both represent sample values. If the two samples have been drawn from the same population, the cumulative distributions of the samples should be fairly close to each other, showing only random deviations from the population distribution. If the cumulative distributions show a large enough maximum deviation D, it is evidence for rejecting the H_0. To secure the maximum deviation, one should use as many intervals as are available so as not to obscure the maximum cumulative difference.

The two-samples KS formula is

$$D = maximum \ |F_{N1}(X) - F_{N2}(X)| \ \text{(two-tailed test)}$$

$$D = maximum \ |F_{N1}(X) - F_{N2}(X)| \ \text{(one-tailed test)}$$

D is calculated in the same manner as before, but the table for critical values for the numerator of D, K_D (two-samples test) is presented in Appendix C, Exhibit C-6, when $n_1 = n_2$ and is less than 40 observations. When n_1 and/or n_2 is larger than 40, D from Appendix C, Exhibit C-7, should be used. With this larger sample, it is not necessary that $n_1 = n_2$.

Here we use a different sample from a tobacco industry advertising study. Suppose the smoking classifications represent an ordinal scale (heavy smoker, moderate smoker, non-smoker), and you test these data with KS two-samples test for young and old age groups. Proceed as follows:

1. *Null hypothesis.*

    H_0: There is no difference in ages of smokers and nonsmokers.

    H_A: The older the person, the more likely he or she is to be a heavy smoker.

2. *Statistical test.* The KS two-samples test is used because it is assumed the data are ordinal.

3. *Significance level.* $\alpha = .05.$ $n_1 = n_2 = 34.$

4. *Calculated value.* See the one-sample calculation (KS test) and compare with the table below.

5. *Critical test value.* We enter Appendix C, Exhibit C-6, with $n = 34$ to find that $K_D = 11$ when $p \leq .05$ for a one-tailed distribution.

	Heavy Smoker	Moderate Smoker	Nonsmoker
$F_o(X)$	12/34	21/34	34/34
$F_n(X)$	4/34	10/34	34/34
$d = K_D$	8/34	11/34	0

6. *Interpretation.* Since the critical value equals the largest calculated value, we reject the null hypothesis.

Mann-Whitney U Test

This test is also used with two independent samples if the data are at least ordinal; it is an alternative to the t-test without the latter's limiting assumptions. When the larger of the two samples is 20 or less, there are special tables for interpreting U; when the larger sample exceeds 20, a normal curve approximation is used.

In calculating the U test, treat all observations in a combined fashion and rank them, algebraically, from smallest to largest. The largest negative score receives the lowest rank. In case of ties, assign the average rank as in other tests. With this test, you can also test samples that are unequal. After the ranking, the rank values for each sample are totaled. Compute the U statistic as follows:

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

or

$$U = n_1 n_2 + \frac{n_2(n_2 - 1)}{2} - R_2$$

in which

n_1 = number in sample 1

n_2 = number in sample 2

R_1 = sum of ranks in sample 1

With this equation, you can secure two U values, one using R_1 and the second using R_2. For testing purposes, use the smaller U.

An example may help to clarify the U statistic calculation procedure. Let's consider the sales training example with the t distribution discussion. Recall that salespeople with training method A averaged higher sales than salespeople with training method B. While these data are ratio measures, one still might not want to accept the other assumptions that underlie the t-test. What kind of a result could be secured with the U test? While the U test is designed for ordinal data, it can be used with interval and ratio measurements.

1. *Null hypothesis.*

   H_0: There is no difference in sales results produced by the two training methods.

   H_A: Training method A produces sales results superior to the results of method B.

2. *Statistical test.* The Mann-Whitney U test is chosen because the measurement is at least ordinal, and the assumptions under the parametric t-test are rejected.

3. *Significance level.* $\alpha = .05$ (one-tailed test).

4. *Calculated value.*

Sales per Week per Salesperson			
Training Method A	Rank	Training Method B	Rank
1,500	15	1,340	10
1,540	16	1,300	8.5
1,860	22	1,620	18
1,230	6	1,070	3
1,370	12	1,210	5
1,550	17	1,170	4
1,840	21	1,770	20
1,250	7	950	1
1,300	8.5	1,380	13
1,350	11	1,460	14
1,710	19	1,030	2
$R_1 = 154.5$		$R_2 = 98.5$	

$$U = (11)(11) + \frac{11(11 + 1)}{2} - 154.5 = 32.5$$

$$U = (11)(11) + \frac{11(11 + 1)}{2} - 98.5 = 88.5$$

5. *Critical test value.* Enter Appendix C, Exhibit C-9, with $n_1 = n_2 = 11$, and find a critical value of 34 for $\alpha = 0.5$, one-tailed test. Note that with this test, the calculated value must be smaller than the critical value to reject the null hypothesis.

6. *Interpretation.* Since the calculated value is smaller than the critical value (34 > 32.5), reject the null hypothesis and conclude that training method A is probably superior.

Thus, one would reject the null hypothesis at $\alpha = .05$ in a one-tailed test using either the t- or the U test. In this example, the U test has approximately the same power as the parametric test.

When $n > 20$ in one of the samples, the sampling distribution of U approaches the normal distribution with

$$\text{Mean} = \mu_U = \frac{n_1 n_2}{2}$$

$$\text{Standard deviation } \sigma_U = \sqrt{\frac{(n_1)(n_2)(n_1 + n_2 + 1)}{12}}$$

and

$$z = \frac{U - \mu_U}{\sigma_U}$$

Other Nonparametric Tests

Other tests are appropriate under certain conditions when testing two independent samples. When the measurement is only nominal, the Fisher exact probability test may be used. When the data are at least ordinal, use the median and Wald-Wolfowitz runs tests.

k-Samples Tests

You can use tests more powerful than χ^2 with data that are at least ordinal in nature. One such test is an extension of the median test mentioned earlier. We illustrate here the application of a second ordinal measurement test known as the Kruskal-Wallis one-way analysis of variance.

Kruskal-Wallis Test

This is a generalized version of the Mann-Whitney test. With it we rank all scores in the entire pool of observations from smallest to largest. The rank sum of each sample is then calculated, with ties being distributed as in other examples. We then compute the value of H as follows:

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{k} \frac{T_j^2}{n_j} - 3(N+1)$$

where

T_j = sum of ranks in column j

n_j = number of cases in jth sample

$N = \Sigma w_j$ = total number of cases

k = number of samples

When there are a number of ties, it is recommended that a correction factor (C) be calculated and used to correct the H value as follows:

$$C = 1 - \left\{ \frac{\sum_{i}^{G} (t_i^3 - t_i)}{N^3 - N} \right\}$$

where

G = number of sets of tied observations

t_i = number tied in any set i

$$H' = H/C$$

To secure the critical value for H', use the table for the distribution of χ^2 (see Appendix C, Exhibit C-3), and enter it with the value of H' and d.f. $= k - 1$.

To illustrate the application of this test, use the price discount experiment problem. The data and calculations are shown in Exhibit b-1 and indicate that, by the Kruskal-Wallis test, one again barely fails to reject the null hypothesis with $\alpha = .05$.

> Exhibit b-1 Kruskal-Wallis One-Way Analysis of Variance (price differentials)

One Cent		Three Cents		Five Cents	
X_A	Rank	X_B	Rank	X_C	Rank
6	1	8	5	9	8.5
7	2.5	9	8.5	9	8.5
8	5	8	5	11	14
7	2.5	10	11.5	10	11.5
9	8.5	11	14	14	18
11	14	13	16.5	13	16.5
	$T_j = 33.5$		60.5		77.0

$$T = 33.5 + 60.5 + 77.0$$

$$= 171$$

$$H = \frac{12}{18(18 + 1)}\left[\frac{33.5^2 + 60.5^2 + 77^2}{6}\right] - 3(18 + 1)$$

$$= \frac{12}{342}\left[\frac{1,122.25 + 3,660.25 + 5,929}{6}\right] - 57$$

$$= 0.0351\left[\frac{10,711.5}{6}\right] - 57$$

$$H = 5.66$$

$$C = 1 - \left(\frac{3[(2)^3 - 2] + 2[(3)^3 - 3] + 4[(4)^3 - 4]}{18^3 - 18}\right)$$

$$= 1 - \frac{18 + 48 + 60}{5814}$$

$$= .978$$

$$H' = \frac{H}{C} = \frac{5.66}{.978} = 5.79$$

$$d.f. = k - 1 = 2$$

$$p > .05$$

>appendixc

Selected Statistical Tables

> **Exhibit C-1** Areas of the Standard Normal Distribution

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
				Second Decimal Place in z						
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995
3.3	0.4995	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998
4.0	0.4999997									
5.0	0.499999999									

> Exhibit C-2 Critical Values of *t* for Given Probability Levels

	Level of Significance for One-Tailed Test					
	.10	.05	.025	.01	.005	.0005
	Level of Significance for Two-Tailed Test					
d.f.	.20	.10	.05	.02	.01	.001
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.598
3	1.638	2.353	3.182	4.541	5.841	12.941
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.859
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073
21	1.323	1.721	2.080	2.518	2.831	3.819
22	1.321	1.717	2.074	2.508	2.819	3.792
23	1.319	1.714	2.069	2.500	2.807	3.767
24	1.318	1.711	2.064	2.492	2.797	3.745
25	1.316	1.708	2.060	2.485	2.787	3.725
40	1.303	1.684	2.021	2.423	2.704	3.551
60	1.296	1.671	2.000	2.390	2.660	3.460
120	1.289	1.658	1.980	2.358	2.617	3.373
∞	1.282	1.645	1.960	2.326	2.576	3.291

Source: Abridged from Table III of Fisher and Yates, *Statistical Tables for Biological, Agricultural, and Medical Research,* 6th ed., published by Oliver and Boyd Ltd., Edinburgh, 1963. By permission of the publishers.

> **Exhibit C-3** Critical Values of the Chi-Square Distribution
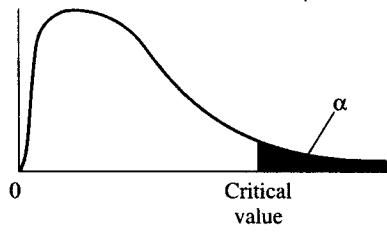
d.f.	Probability				
	.10	.05	.02	.01	.001
1	2.71	3.84	5.41	6.64	10.83
2	4.60	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.34	16.27
4	7.78	9.49	11.67	13.28	18.46
5	9.24	11.07	13.39	15.09	20.52
11	17.28	19.68	22.62	24.72	31.26
12	18.55	21.03	24.05	26.22	32.91
13	19.81	22.36	25.47	27.69	34.53
14	21.06	23.68	26.87	29.14	36.12
15	22.31	25.00	28.26	30.58	37.70
21	29.62	32.67	36.34	38.93	46.80
22	30.81	33.92	37.66	40.29	48.27
23	32.01	35.17	38.97	41.64	49.73
24	33.20	36.42	40.27	42.98	51.18
25	34.38	37.65	41.57	44.31	52.62

> **Exhibit C-4** Critical Values of T in the Wilcoxon Matched-Pairs Test

	Level of Significance for One-Tailed Test		
	.025	.01	.005
	Level of Significance for Two-Tailed Test		
n	.05	.02	.01
6	0	—	—
7	2	0	—
8	4	2	0
9	6	3	2
10	8		
11	11		
12	14	10	
13	17	13	10
14	21	16	13
15	25	20	16
16	30	24	20
17	35	28	23
18			
19			
20			
21	59	49	43
22	66	56	49
23	73	62	55
24	81	69	61
25	89	77	68

Source: Adapted from Table 1 of F. Wilcoxon, *Some Rapid Approximate Statistical Procedures* (New York: American Cyanamid Company, 1949), p. 13, with the kind permission of the publisher.

> **Exhibit C-5** Critical Values of D in the Kolmogorov-Smirnov One-Sample Test

Sample Size n	Level of Significance for D = Maximum $F_0(X) - S_N(X)$				
	.20	.15	.10	.05	.01
1	.900	.925	.950	.975	.995
2	.684	.726	.776	.842	.929
3	.565	.597	.642	.708	.828
4	.494	.525	.564	.624	.733
5	.446	.474	.510	.565	.669
11	.301	.326	.352	.391	.468
12	.291	.313	.338	.375	.450
13	.281	.302	.325	.361	.433
14	.274	.292	.314	.349	.418
15	.266	.283	.304	.338	.404
25	.21	.22	.24	.27	.32
30	.19	.20	.22	.24	.29
35	.18	.19	.21	.23	.27
Over 35	$\dfrac{1.07}{\sqrt{N}}$	$\dfrac{1.14}{\sqrt{N}}$	$\dfrac{1.22}{\sqrt{N}}$	$\dfrac{1.36}{\sqrt{N}}$	$\dfrac{1.63}{\sqrt{N}}$

> **Exhibit C-6** Critical Values of K_D in the Kolmogorov-Smirnov Two-Samples Test (small samples)

n	One-Tailed Test		Two-Tailed Test	
	$\alpha = .05$	$\alpha = .01$	$\alpha = .05$	$\alpha = .01$
3	3	—	—	—
4	4	—	4	—
5	4	5	5	5
6	5	6	5	6
7	5	6	6	6
13	7	8	7	9
14	7	8	8	9
15	7	9	8	9
16	7	9	8	10
17	8	9	8	10
23	9	11	10	11
24	9	11	10	12
25	9	11	10	12
26	9	11	10	12
27	9	12	10	12

> **Exhibit C-7** Critical Values of D in the Kolmogorov-Smirnov
Two-Samples Test for Large Samples (two-tailed)

Level of Significance	Value of D So Large as to Call for Rejection of H_0 at the Indicated Level of Significance, Where $D = \text{Maximum } |S_{n_1}(X) - S_2(X)|$
.10	$1.22 \sqrt{\dfrac{n_1 + n_2}{n_1 n_2}}$
.025	$1.48 \sqrt{\dfrac{n_1 + n_2}{n_1 n_2}}$
.005	$1.73 \sqrt{\dfrac{n_1 + n_2}{n_1 n_2}}$

> **Exhibit C-8** Critical Values of the F Distribution for $\alpha = .05$

n_2	Degrees of Freedom for Numerator								
	1	2	3	4	5	6	7	8	9
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88

Source: Reprinted by permission from *Statistical Methods* by George W. Snedecor and William G. Cochran, 6th edition, © 1967 by Iowa State University Press, Ames, Iowa.

Degrees of Freedom for Numerator (cont'd)									
10	12	15	20	24	30	40	80	120	∞
241.9	243.9	245.9	248.0	249.1	250.1	251.1	252.2	253.3	243.3
19.40	19.41	19.43	19.45	19.45	19.46	19.47	19.48	19.49	19.50
8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.36
2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

> **Exhibit C-9** Partial Table of Critical Values of U in the Mann-Whitney Test

	Critical Values for One-Tailed Test at $\alpha = .025$ or Two-Tailed Test at $\alpha = .05$											
$n_1 \backslash n_2$	9	10	11	12	13	14	15	16	17	18	19	20
1												
2	0	0	0	1	1	1	1	1	2	2	2	2
3	2	3	3	4	4	5	5	6	6	7	7	8
4	4	5	6	7	8	9	10	11	11	12	13	13
5	7	8	9	11	12	13	14	15	17	18	19	20
11	23	26	30	33	37	40	44	47	51	55	58	62
12	26	29	33	37	41	45	49	53	57	61	65	69
13	28	33	37	41	45	50	54	59	63	67	72	76
14	31	36	40	45	50	55	59	64	67	74	78	83
15	34	39	44	49	54	59	64	70	75	80	85	90

	Critical Values for One-Tailed Test at $\alpha = .05$ or Two-Tailed Test at $\alpha = .10$											
$n_1 \backslash n_2$	9	10	11	12	13	14	15	16	17	18	19	20
1											0	0
2	1	1	1	2	2	2	3	3	3	4	4	4
3	3	4	5	5	6	7	7	8	9	9	10	11
4	6	7	8	9	10	11	12	14	15	16	17	18
5	9	11	12	13	15	16	18	19	20	22	23	25
11	27	31	34	38	42	46	50	54	57	61	65	69
12	30	34	38	42	47	51	55	60	64	68	72	77
13	33	37	42	47	51	56	61	65	70	75	80	84
14	36	41	46	51	56	61	66	71	77	82	87	92
15	39	44	50	55	61	66	72	77	83	88	94	100

> **Exhibit C-10** Random Numbers

87446	30328	05262	77371	13523	62057	44349	85884	94555	23258
15453	75691	60540	77137	09485	27632	05477	99154	78720	10323
69995	77086	55217	53721	85713	27854	41981	88981	90041	20878
69726	58696	27272	38148	52521	73807	29685	49152	20309	58734
23604	31948	16926	26360	76957	99925	86045	11617	32777	38670
13640	17233	58650	47819	24935	28670	33415	77202	92492	40290
90779	09199	51169	94892	34271	22068	13923	53535	56358	50258
71068	19459	32339	10124	13012	79706	07611	52600	83088	26829
55019	79001	34442	16335	06428	52873	65316	01480	72204	39494
20879	60235	17389	25260	34039	99967	48044	05067	69284	53867
00380	11595	49372	95214	98529	46593	77046	27176	39668	20566
68142	40800	20627	79212	14166	84948	11748	69540	84288	37211
42667	69568	20440	57230	35356	01884	79921	94772	29882	24695
07756	78430	45576	86596	56720	65529	44211	18447	53921	92722
45221	31130	44512	63534	47741	02465	50629	94983	05984	88375
20140	77481	61686	82836	41058	41331	04290	61212	60294	95954
54922	25436	33604	51907	73223	66423	68706	36589	45267	35927
48340	30892	72209	07644	52747	40751	06808	85349	18005	52323
23603	64387	20416	88084	33103	41511	59391	71600	35091	52722
12548	01033	22974	59596	92087	02116	63524	00627	41778	24392
15251	87584	12942	03771	91413	75652	19468	83889	98531	91529
65548	59670	57355	18874	63601	55111	07278	32560	40028	38079
48488	76170	46282	76427	41693	04506	80979	26654	62159	83017
02862	15665	62159	15159	69576	20328	68873	28152	66087	39405
67929	06754	45842	66365	80848	15262	55144	37816	08421	30071
73237	07607	91615	04892	50989	87347	14393	21165	68169	70788
13788	20327	07960	95917	75112	01398	26381	41377	33549	19754
43877	66485	40825	45923	74410	69693	76959	70973	26343	63781
14047	08399	56414	78533	76378	44204	71493	68861	31042	81873
88383	46755	51342	13505	55324	52950	22244	28028	79486	98797
29567	16379	41994	65947	58926	50953	09388	00405	29874	44954
20508	60995	41539	26396	99825	25652	28089	57224	35222	58922
64178	76768	75747	32854	32893	61152	58565	33128	33354	16056
26373	51147	90962	93309	13175	66385	57822	31138	12893	68607
10083	47658	59241	73630	99200	94672	59785	95449	99279	25488
11683	14347	04369	98719	75005	43633	24125	30532	54830	95387
56646	76293	50904	88579	24621	94291	56881	35062	48766	22078
85292	47291	82610	27777	43965	31802	98444	88929	54393	93141
51329	87645	51623	08971	50704	82395	33916	95859	99788	97885
51860	19160	39324	68483	78650	74750	64893	58042	82878	20619
23896	01257	07945	71175	31243	87167	42829	44601	08769	26417
80028	82310	43989	09242	15056	48250	04529	96941	48190	69644
83946	46858	09164	18858	12672	55190	02820	45861	29104	75386
00000	41586	25972	25356	54260	95691	99431	89903	22306	43863
90615	12648	23376	29458	48239	37628	59265	50152	30340	40713
42003	10738	55835	48218	23204	19188	13556	06610	77667	88068
86135	26174	07834	17007	97938	96728	15689	77544	89186	41252
54436	10828	41212	19836	89476	53685	28085	22878	71868	35048
14545	72034	32131	38783	58588	47499	50945	97045	42357	53536
43925	49879	13339	78773	95626	67119	93023	96832	09757	98845

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5. While this might intuitively seem to be the case, consider that one might prefer a over b, b over c, yet c over a. These results cannot be scaled as ordinal data because there is apparently more than one dimension involved.

6. Parametric tests are appropriate when the measurement is interval or ratio and when we can accept certain assumptions about the underlying distributions of the data with which we are working (normality, independence, constant variance). Nonparametric tests usually involve much weaker assumptions about measurement scales (nominal and ordinal), and the assumptions about the underlying distribution of the population are fewer and less restrictive. More on these tests is found in Chapters 18 and 19 and Appendix B.

7. *Statistical power* is the probability of detecting a meaningful difference if one were to occur. Studies should have power levels of 0.80 or higher, i.e., an 80% chance or greater of discerning an effect if one was really there.

8. See Chapters 18 and 19 for a discussion of these procedures.

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5. Proportions are hypothetical. *Advertising Age* recognized Serta's "Counting Sheep 'Penalty'" ad as one of the campaign's most effective for brand recall. Serta ranked eighth, using rankings from more than 2.6 million surveys of TV viewers from January 2 to April 1, 2003. This same campaign won a prestigious Gold Effie award in June 2002. Serta spends $20 million annually on the sheep campaign. "Counting Sheep Scheme to Win Back Client in Serta's New TV Commercials," Serta press release, downloaded November 23, 2003 (http://www.serta.com/ pressrelease/press_r2.pdf); "Ad Age Recognizes Serta," *Furniture Today* press release, downloaded November 23, 2003 (http://www.furnituretoday.com/cgi-bin/v2/showArchive.cgi?num=942&news=Ad%20Age%20recognizes%20Serta); *Advertising Age,* April 21, 2003.
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10. Standard international sampling systems are based on standards such as ISO 2859 and ISO 3951.

11. All estimates of costs are hypothetical.

12. Leslie Kish, *Survey Sampling* (New York: Wiley, 1965), p. 188.

13. Ibid., pp. 76–77.

14. Typically, stratification is carried out before the actual sampling, but when this is not possible, it is still possible to stratify after the fact. Ibid., p. 90.

15. W. G. Cochran, *Sampling Techniques*, 2d ed. (New York: Wiley, 1963), p. 134.

16. Ibid., p. 96.

17. Kish, *Survey Sampling*, p. 94.

18. For detailed treatment of these and other cluster sampling methods and problems, see ibid., pp. 148–247.

19. J. H. Lorie and H. V. Roberts, *Basic Methods of Marketing Research* (New York: McGraw-Hill, 1951), p. 120.

20. Kish, *Survey Sampling*, p. 156.

21. For specifics on these problems and how to solve them, the reader is referred to the many good sampling texts. Two that have been mentioned already are Kish, *Survey Sampling*, chaps. 5, 6, and 7, and Cochran, *Sampling Techniques*, chaps. 9, 10, and 11.

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appendix 15a

Reference Notes

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1. A proportion is the mean of a dichotomous variable when members of a class receive the value of 1, and nonmembers receive a value of 0.

chapter 16

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3. Klaus Krippendorff, *Content Analysis: An Introduction to Its Methodology* (Beverly Hills, CA: Sage Publications, 1980), p. 22.

4. Based on the operation of the SPSS, Inc., product TextSmart.

5. Hans Zeisel, *Say It with Figures*, 6th ed. (New York: Harper & Row, 1985), pp. 48–49.

6. "Technology Overview," TraxUK, downloaded March 11, 2003 (http//www.trax-uk.co.uk./technology).

7. Ibid.

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4. The exhibits in this section were created with statistical and graphic programs particularly suited to exploratory data analysis. The authors acknowledge the following vendors for evaluation and use of their products: SPSS, Inc., 233 S. Wacker Dr., Chicago, IL 60606; and Data Description, P.O. Box 4555, Ithaca, NY 14852.

5. Paul F. Velleman and David C. Hoaglin, *Applications, Basics, and Computing of Exploratory Data Analysis* (Boston: Duxbury Press, 1981), p. 13.

6. John Hanke, Eastern Washington University, contributed this section. For further references to stem-and-leaf displays, see John D. Emerson and David C. Hoaglin, "Stem-and-Leaf Displays," in *Understanding Robust and Exploratory Data Analysis*, pp. 7–31, and Velleman and Hoaglin, *Applications*, pp. 1–13.

7. This section is adapted from the following excellent discussions of boxplots: Velleman and Hoaglin, *Applications*, pp. 65–76; Hartwig, *Exploratory Data Analysis*, pp. 19–25; John D. Emerson and Judith Strenio, "Boxplots and Batch Comparison," in *Understanding Robust and Exploratory Data Analysis*, pp. 59–93; and Amir D. Aczel, *Complete Business Statistics* (Homewood, IL: Irwin, 1989), pp. 723–28.

8. Tukey, *Exploratory Data Analysis*, pp. 27–55.

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10. Several robust estimators that are suitable replacements for the mean and standard deviation we do not discuss here—for example, the trimmed mean, trimean, the M-estimators (such as Huber's, Tukey's, Hampel's, and Andrew's estimators), and the median absolute deviation (MAD). See Hoaglin et al., *Understanding Robust and Exploratory Data Analysis*, chap. 10, and SPSS, Inc., *SPSS Base 9.0 User's Guide* (Chicago: SPSS, 1999), chap. 13.

11. The difference between the definitions of a hinge and a quartile is based on variations in their calculation. We use Q_1, *25th percentile*, and *lower hinge* synonymously; and Q_3, *75th percentile*, and *upper hinge*, similarly. There are technical differences, although they are not significant in this context.

12. R. McGill, J. W. Tukey, and W. A. Larsen, "Variations of Box Plots," *The American Statistician* 14 (1978), pp. 12–16.

13. See J. Chambers, W. Cleveland, B. Kleiner, and John W. Tukey, *Graphical Methods for Data Analysis* (Boston: Duxbury Press, 1983).

14. Harper W. Boyd Jr. and Ralph Westfall, *Marketing Research*, 3d ed. (Homewood, IL: Irwin, 1972), p. 540.

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chapter 18

Reference Notes

1. A more detailed example is found in Amir D. Aczel and Jayauel Sounderpandian, *Complete Business Statistics,* 5th ed. (New York: Irwin/McGraw-Hill, 2001).

2. The standardized random variable, denoted by Z, is a deviation from expectancy and is expressed in terms of standard deviation units. The mean of the distribution of a standardized random variable is 0, and the standard deviation is 1. With this distribution, the deviation from the mean by any value of X can be expressed in standard deviation units.

3. Procedures for hypothesis testing are reasonably similar across authors. This outline was influenced by Sidney Siegel, *Nonparametric Statistics for the Behavioral Sciences* (New York: McGraw-Hill, 1956), chap. 2.

4. Marija J. Norusis/SPSS, Inc., *SPSS for Windows Base System User's Guide,* Release 6.0 (Chicago: SPSS, 1993), pp. 601–06.

5. For further information on these tests, see ibid., pp. 187–88.

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7. Statistical Navigator is a product from The Idea Works, Inc.

8. Exhibit 18-7 is partially adapted from Siegel, *Nonparametric Statistics,* flyleaf.

9. See B. S. Everitt, *The Analysis of Contingency Tables* (London: Chapman and Hall, 1977).

10. The critiques are represented by W. J. Conover, "Some Reasons for Not Using the Yates' Continuity Correction on 2 × 2 Contingency Tables," *Journal of the American Statistical Association* 69 (1974), pp. 374–76, and N. Mantel, "Comment and a Suggestion on the Yates' Continuity Correction," *Journal of the American Statistical Association* 69 (1974), pp. 378–80.

11. This data table and the analysis of variance tables and plots in this section were prepared with SuperANOVA™.

12. See, for example, Roger E. Kirk, *Experimental Design: Procedures for the Behavioral Sciences* (Belmont, CA: Brooks/Cole, 1982), pp. 115–33. An exceptionally clear presentation for step-by-step hand computation is found in James L. Bruning and B. L. Kintz, *Computational Handbook of Statistics,* 2d ed. (Glenview, IL: Scott, Foresman, 1977), pp. 143–68. Also, when you use a computer program, the reference manual typically provides helpful advice in addition to the setup instructions.

13. Kirk, *Experimental Design,* pp. 90–115. Alternatively, see Bruning and Kintz, *Computational Handbook of Statistics,* pp. 113–32.

14. For a discussion and example of the Cochran Q test, see Sidney Siegel and N. J. Castellan Jr., *Nonparametric Statistics for the Behavioral Sciences,* 2d ed. (New York: McGraw-Hill, 1988).

15. For further details, see ibid.

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chapter 19

Reference Notes

1. Typically, we plot the X (independent) variable on the horizontal axis and the Y (dependent) variable on the vertical axis. Although correlation does not distinguish between independent and dependent variables, the convention is useful for consistency in plotting and will be used later with regression.

2. F. J. Anscombe, "Graphs in Statistical Analysis," *American Statistician* 27 (1973), pp. 17–21. Cited in Samprit Chatterjee and Bertram Price, *Regression Analysis by Example* (New York: Wiley, 1977), pp. 7–9.

3. Amir D. Aczel, *Complete Business Statistics*. 2d ed. (Homewood, IL: Irwin, 1993), p. 433.

4. This section is partially based on the concepts developed by Emanuel J. Mason and William J. Bramble, *Understanding and Conducting Research* (New York: McGraw-Hill, 1989), pp. 172–82, and elaborated in greater detail by Aczel, *Complete Business Statistics*, pp. 414–29.

5. Technically, estimation uses a concurrent criterion variable where prediction uses a future criterion. The statistical procedure is the same in either case.

6. Roz Howard and Jenny Stonier, "Marketing Wine to Generation X" for the 2000–2001 NSW Wine Press Club Fellowship. Reported in Murray Almond's "From the Left Island," May 25, 2002 (http://www.wineoftheweek.com/murray/0205genx.html).

7. Peter Passell, "Can Math Predict a Wine? An Economist Takes a Swipe at Some Noses," *International Herald Tribune*, March 5, 1990, p. 1; Jacques Neher, "Top Quality Bordeaux Cellar Is an Excellent Buy," *International Herald Tribune*, July 9, 1990, p. 8.

8. See Alan Agresti and Barbara Finlay, *Statistical Methods for the Social Sciences* (San Francisco: Dellen Publishing, 1986), pp. 248–49. Also see the discussion of basic regression models in John Neter, William Wasserman, and Michael H. Kutner, *Applied Linear Statistical Models* (Homewood, IL: Irwin, 1990), pp. 23–49.

9. We distinguish between the error terms $\varepsilon_i = Y_i - EY_i$ and the residual $e_i = (Y_i - \hat{Y}_i)$. The first is based on the vertical deviation of Y_i from the true regression line. It is unknown and estimated. The second is the vertical deviation of Y_i

from the fitted $\hat{Y}$ on the estimated line. See Neter et al., *Applied Linear Statistical Models*, p. 47.

10. For further information on software-generated regression diagnostics, see the most current release of software manuals for SPSS, MINITAB, BMDP, and SAS.

11. Aczel, *Complete Business Statistics*, p. 434.

12. This calculation is normally listed as the standard error of the slope (SE B) on computer printouts. For these data it is further defined as

$$s(b_i) + \frac{8}{\sqrt{SS_x}} = \frac{538.559}{\sqrt{198.249}} = 38.249$$

where

s = the standard error of estimate (and the square root of the mean square error of the regression)

SS_x = the sum of squares for the X variable

13. Computer printouts use uppercase (R^2) because most procedures are written to accept multiple and bivariate regression.

14. The table output for this section has been modified from SPSS and is described in Marija J. Norusis/SPSS, Inc., *SPSS Base System User's Guide* (Chicago: SPSS, 1990). For further discussion and examples of nonparametric measures of association, see S. Siegel and N. J. Castellan Jr., *Nonparametric Statistics for the Behavioral Sciences*, 2d ed. (New York: McGraw-Hill, 1988).

15. Calculation of concordant and discordant pairs is adapted from Agresti and Finlay, *Statistical Methods for the Social Sciences*, pp. 221–23.

16. We know that the percentage of concordant plus the percentage of discordant pairs sums to 1.0. We also know their difference is −.70. The only numbers satisfying these two conditions are .85 and .15 (.85 + .15 = 1.0, .15 − .85 = −.70).

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8. This section was prepared by Jeff Stevens, School of Public Administration, Florida Atlantic University. For further information, see J. Hair, R. Anderson, R. Tatham, and W. Black, *Multivariate Data Analysis with Readings,* 5th ed. (Upper Saddle River, NJ: Prentice Hall, 1998); J. Scott Long, *Covariance Structure Models: An Introduction to LISREL* (Thousand Oaks, CA: Sage Publications, 1984); J. Scott Long, *Confirmatory Factor Analysis: A Preface to LISREL* (Thousand Oaks, CA: Sage Publications, 1983); and Barbara M. Byrne, *A Primer of LISREL: Basic Applications and Programming for Confirmatory Factor Analytic Models* (New York: Springer-Verlag, 1989).
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