DOCUMENT RESUME

ED 342 056 EA 023 510

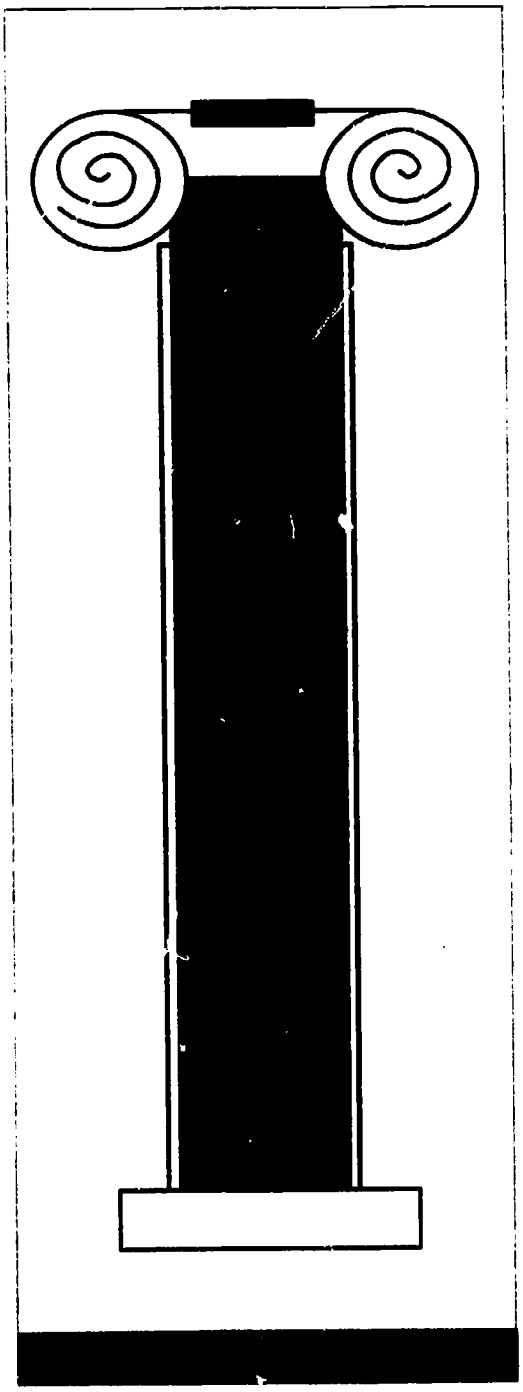
AUTHOR Charters, W. W., Jr.
TITLE Understanding Variables & Hypotheses in Scientific Research.
INSTITUTION ERIC Clearinghouse on Educational Management, Eugene, Oreg.
SPONS AGENCY Office of Educational Research and Improvement (ED), Washington, DC.
REPORT NO ISBN-0-86552-115-8
PUB DATE 92
CONTRACT RI88062004
NOTE 53p.
AVAILABLE FROM ERIC Clearinghouse on Educational Management, University of Oregon, 1787 Agate Street, Eugene, OR 97403 ($5.95; $2.50 handling charge on billed orders).
PUB TYPE Reports - Research/Technical (143) -- Guides - Non-Classroom Use (055) -- Information Analyses -- ERIC Clearinghouse Products (071)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Classification; Educational Administration; *Educational Research; Higher Education; *Hypothesis Testing; *Research Methodology; Research Problems; *Scientific Research
IDENTIFIERS *Variables

ABSTRACT

The hypothesis is the device scientists use to translate questions, theories, or proposed explanations into a form amenable to empirical research. This edition of W. W. Charter's treatise on clear, conceptual definitions and precise operational hypotheses, which was originally developed to assist students in educational policy and management courses is designed to bring this brief but classic work to a larger audience. Written for novices in research, the manual is a discussion of the ways in which variables and hypotheses appear in research, the functions they serve, and common problems that researchers have with them. It introduces distinctions and rules and procedures for unraveling variables, examining relationships between them, and analyzing hypotheses. The manual contains five chapters. Chapter 1 explains that the hypothesis, in its elementary form, consists of two variables and a specification of the relationship that one expects to hold between them. Chapter 2 introduces the essence of variables using three general terms--objects, properties of objects, and values of a property--and the two modes of variation--kind and degree. Chapter 3 ventures into the subject of relationships between variables. Chapter 4 delves into the "anatomy of the hypothesis" and discusses the unit of analysis, the null hypothesis, and how to locate and dissect hypotheses in published studies. Finally, the last chapter concerns the two major classes of "diseases" that prevent hypotheses from growing into proper form: those that afflict variables and those that attack specifications of relationships. (MLF)

ON UNDERSTANDING VARIABLES & HYPOTHESES IN SCIENTIFIC RESEARCH



W. W. CHARTERS, JR.

With a Foreword by Richard A. Schmuck

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1992

Design: LeeAnn August

International Standard Book Number: 0-86552-115-8
Library of Congress Catalog Card Number: 91-77518
ERIC/CEM Accession Number: EA 023 510

Printed in the United States of America, 1992
ERIC Clearinghouse on Educational Management
University of Oregon, Eugene, OR 97403

Prior to publication, this manuscript was submitted for critical review and determination of professional competence. The publication has met such standards. The publication was prepared with funding from the Office of Educational Research and Improvement, U.S. Department of Education, under contract no. OERI-R 188062004. The opinions expressed in this report do not necessarily reflect the positions or policies of the Department of Education.

No federal funds were used in the printing of this publication.

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PREFACE

The opportunity to publish this instructional manual occurred quite by chance in early October 1991 when Sandy left a typewritten copy on my desk with a handwritten note telling me that he was tired of answering requests for copies and asking if I would consider "putting it in ERIC." Realizing at once that this was the material that Sandy had used for so many years in his policy research course at Oregon, I immediately called him and suggested that instead of merely putting the work in the ERIC database, he should allow the Clearinghouse to publish it. Fortunately for us, and for those who will now have an opportunity to read this classic work, Sandy agreed.

For anyone doing empirical research today—be they graduate student, beginning academic, or established scholar—this manual should be read and reread again, again, and again. All will benefit from Sandy's wise, witty, and lucid discourse on the "distinctions and rules and procedures for unraveling variables, examining relationships between them, and analyzing hypotheses." And for those of his students, colleagues, and friends whose professional lives were enriched by Sandy, this work will stand as a lasting reminder of the remarkable gifts of this brilliant teacher and distinguished scholar.

On Understanding Variables and Hypotheses is destined to do for scientific research what *Elements of Style* did for writing.

Philip K. Piele
Professor and Director

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FOREWORD

For thirty years Sandy Charters elegantly lectured about research methods to hundreds of doctoral aspirants in educational policy and management at Washington University and the University of Oregon. With emotional warmth and intellectual precision, he was determined to contribute to his students' understanding of scientific research, and to their belief in the relevance of positivist reasoning to educational administration.

Today there are hundreds of Oregon graduates worldwide who were profoundly affected by his intelligent grace in the classroom. When those alumni reread this tiny book, they will be transported back in memory to when they sat with Charters in a Eugene classroom. They will think: at last we have printed in a single binding the reading that Charters distributed during his fine two-quarter course on policy research methods. Readers who never heard Charters lecture, moreover, will find his systematic and logical dissection of variables and hypotheses insightful and practical. This book has come at the right time.

What Charters contributes here is just what is needed today to correct a current bias and tilt in favor of qualitative methods. In the face of a paradigm shift in policy research in which qualitative methods are being exalted and quantitative methods are being undervalued, Charters's treatise on clear conceptual definitions and precise operational hypotheses will play a pivotal role, I hope, in reintegrating the best of both the qualitative and the quantitative traditions. I urge students who wish to carry out case studies or ethnographic descriptions to prepare a concrete research plan by heeding self-consciously Charters's advice to define clearly and precisely the variables under study.

Born a few days before Christmas seventy years ago, W.W. Charters, Jr. was raised with books near his crib in an intellectual home under the shadow of Ohio State University (OSU). His father was director of the Bureau of Educational Research; his mother was a professor of adult education. The only son in a four-child family, Charters's sisters all distinguished themselves with advanced graduate degrees, each in a field of human service. Sandy, a nickname he would never outgrow, attended the experimental laboratory school at OSU in Columbus, received a B.A. with honors in sociology from DePauw University, studied summers with L.L. Thurstone, Herbert Blumer, and Carl Rogers at the University of Chicago, and in 1952 received a Ph.D. in social psychology from the University of Michigan, the same doctoral program from which Philip Runkel and I also graduated in 1959 and 1962, respectively.

Among his professional positions, Charters worked in the Bureau of Educational Research at the University of Illinois, alongside Cronbach, Gage, and others, carrying out research on the social organization of the school, and he explored alternative ways of understanding educational issues with Callahan, DeCharms, and L. Smith at Washington University in St. Louis. In 1966, he moved to the Center for the Advanced Study of Educational Administration at Oregon. By the time he retired in 1987, Charters had produced ten books or monographs and over fifty articles or chapters. Most distinctive among his books were two volumes of readings in the social psychology of education that he coedited with Nate Gage and Matt Miles, respectively. *On Understanding Variables and Hypotheses in Scientific Research* is, however, his most personally distinctive product.

Nevertheless, it is a mistake to overemphasize the importance of his publications, for it was Sandy Charters, the professor, who will be remembered more vividly by his students and colleagues. He sparkled and glowed as he probed students for their ideas about variables and their speculations about hypotheses. By probing the meaning of his students' variables and hypotheses, he prodded them to achieve clarity and precision in their research plans. He tactfully persuaded and painstakingly helped students to relate conceptual definitions logically to operational definitions. As one student told me, "Instead of giving me answers, Charters helps me to ask the right questions of myself." Other students characterized Charters as challenging, curious, helpful, insightful, masterful, meticulous, and forever questioning His students saw him as a "graceful master" of the Socratic method of teaching.

The Sandy Charters I most respected had a passion for conceptualizing social-psychological relationships. He labored diligently at defining networks of relationships between roles and at analyzing how people's locations in a network of communicative relationships constituted the fundamental reality of bureaucratic structures. He believed that individual cognitions and feelings grow out of interpersonal relationships and that human beings are simultaneously social and individual. He understood that the social realities that exist between us are part and parcel of the cognitive and emotional realities within us.

During his retirement party at my home over four years ago, I honored him as one of the top ten social psychologists of education ever. I said that Sandy, still a brilliant young man in my mind, reminded me of Robert Frost's youthful swinger of birches. For in my dreams, I could imagine a golden-haired Sandy keeping "his poise to the top branches, climbing carefully with the same pains you use to fill a cup up to the brim, and even above the brim." In my mind's eye, I could see Sandy leaping out in space and "through the air to the ground" returning securely to earth. I could see that because I believe that Sandy Charters, the master teacher, took great pains to fill the cups of his students and that he always maintained contact with the ground, even as he filled their cups to the brim. I trust that you, too, will see those very special qualities of Sandy Charters in this gem of a book.

Richard A. Schmuck
Professor of Educational
Policy and Management
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January 1992

CHAPTER 1

I

TO START WITH

THE HYPOTHESIS IS A KEY component of research in the behavioral (and other) sciences. It is the device scientists use to translate questions, theories, or proposed explanations into a form amenable to empirical research. In addition, a set of hypotheses laid out at the beginning of a study is an invaluable guide in directing the researcher through the intricacies of collecting and analyzing data.

Exactly what are *hypotheses*? Oddly enough, textbooks and other sources on research methods do not tell you much about hypotheses, and what they do say may even be a bit misleading. The authors seem to assume that you already know what they are. The same thing is true of *variables*, which are the constituent parts of hypotheses. The term is used over and over again by researchers, but you would have to look long and hard to discover what it means. This manual will let you in on the secrets.

The manual is written for novices in research. It introduces distinctions and rules and procedures for unraveling variables, examining relationships between them, and analyzing hypotheses. The purpose of the definitions and procedures is purely instructional. Once you have mastered them, they will become second nature and you will no longer need to go through the fol-de-rol I insist on at first. They will have served their purpose. You should be in a better position to understand the empirical research you read and to plan studies of your own devising.

WHAT'S AHEAD

The hypothesis, in its elementary form, consists of two variables and a specification of the relationship that one expects to hold between them. The variables are like two atoms bonded to create a particular kind of molecule. There is a good bit more to it than this, of course, but the analogy suggests that it will be useful to learn about the atoms and the bonding glue (relationships) before considering the molecule. In fact, two-thirds of the task of understanding the hypothesis will be accomplished once you have a good grasp on the nature of variables. Chapter 2 introduces you to their essence.

In chapter 3, I venture into the subject of relationships between variables. Early on, the chapter deals with the three ways of looking at the relationship between a pair of variables, depending on their "modes of variation" (chapter 2). Contemporary research, though, rarely deals with just two variables. More likely there is a whole closet full of them. It is crucial that you have a way of putting them in order, of recognizing how they stand with respect to one another, and generally making sense of their variety, so the chapter introduces you to some terms that allow you to sort through them.

Chapter 4 gets into the anatomy of the hypothesis itself. Much of what you need to know will already have been covered in chapters 2 and 3, but here the focus is on writing an elementary hypothesis in proper form. Beyond this, several key notions related to the hypothesis will be introduced, including the idea of the "null hypothesis" and where it fits in research and a consideration of hypotheses beyond the elementary variety.

The last chapter takes up some of the more common diseases and pathological forms of hypotheses. My main interest in telling you about the hypothesis is in preventive medicine. I hope that, when all is said and done, you will be able to construct healthy, viable hypotheses of maximum utility in your own research. A malformed hypothesis in the body of a study is often fatal.

EQUIPMENT YOU WILL NEED

The tools you will need for studying variables and hypotheses are simple—paper and pencil, specimens on which to work, and a dissection table. (A white lab coat is optional.) I have provided a number of preserved specimens of variables and hypotheses at various places in the manual on which you are encouraged to exercise your dissection skills. Appropriate locations for finding clinical specimens are studies published in such research journals as:

American Educational Research Journal
Administrative Science Quarterly
Educational Administration Quarterly
Educational Evaluation and Policy Analysis
Journal of Educational Research
Journal of Experimental Education
Sociology of Education

There are numerous other scholarly journals that publish original research, and you would do well to get acquainted with those in your own field of interest. Avoid the popular professional journals in education, though; while they might report summaries of research, they are not good sources of original studies. They rarely say enough about the research to provide dissectable specimens.

You might also try your hand at abstracts of research studies, like *Dissertation Abstracts* (a prime source for pathological hypotheses), *Educational Administration Abstracts*, *Psychological Abstracts*, and the like. Some give enough detail to permit a provisional dissection of the variables and hypotheses of a study, and they furnish the reference to the original source if you need to clear up ambiguities.

CHAPTER 2

THE ESSENCE OF VARIABLES

THIS CHAPTER TELLS YOU SOME important things to know about variables. You will learn:

- What a variable is
- That variables have two basically different "modes of variation": kind and degree
- That there are two special cases of modes of variation: the present-absent mode and ordered categories
- What format to use in describing variables completely and unambiguously
- What puzzling situations you are likely to confront as you try to identify variables in the field and how best to resolve them

DISCOURSE ON WHAT A VARIABLE IS

To explain variables, it is necessary to use three general terms: *objects*, *properties* of objects, and *values* of a property.

OBJECTS AND THEIR PROPERTIES

Objects are the things one does research *on*. They are often people (sixth-grade students, school board members, female athletes), but they can be school districts, nations, small groups, newspaper editorials, or specific events (bond elections, employment of principals).

We intuitively distinguish between things and properties of things in our everyday lives—between an object like "hat" and a property that hats might have, like "color" or "size." This idea is embedded in the difference between a noun and an adjective. We talk about a "large hat," implicitly distinguishing it from other hats that are ordinary or small.

Objects that we see around us have an unlimited number of properties, or attributes, according to which they can be described. These properties enable us to talk about ways objects are alike and ways they are different.

Empirical research is concerned with the way objects differ from one another (or the way a given object differs from one time to the next). A property that allows us to make this distinction between the objects of study is called a *variable*. Consider the following properties, or attributes, that would allow us to differentiate between school principals:

Gender

Height

Rate of speaking

Whether or not afflicted with ulcers

Amount of knowledge about school law

Number of previous administrative positions

Eye color

Level of self-esteem

The list could be continued indefinitely, but the point is that each of these properties could be used as a variable in a study of school principals.

VALUES OF A PROPERTY

A property (or a variable) always implies an associated set of values—at least two—that set objects apart from one another. For instance, size (of a hat) implies a range of values from 6 7/8 or smaller to 7 3/4 or larger. Gender (of a principal) implies two values, male and female. Ulcer affliction might imply two, afflicted and not afflicted. Eye color may entail four or five values or more, depending on how finely one wished to discriminate between principals. Height entails a continuous array of values, usually denoted in feet, inches, and fractions of an inch or perhaps in centimeters, while number of previous administrative positions implies a set of discrete values that might run from 0 to 10 or so.

When used as a variable, the values associated with the property must be *exhaustive* and they must be *mutually exclusive*. A place for everything and everything in its place. An exhaustive set of values means that one must be able to assign some value to all objects under consideration (even if that means providing a value called "information missing").

Mutually exclusive means that each object can be assigned only one of the set of values. A hat cannot be both 6 7/8 and 7 3/4 at the same time.

(Researchers sometimes run into problems as they try to follow these rules in creating classification systems. What do you do about a principal who has one gray eye and one green eye? Answer: establish another value, "mixed.")

VARIABLES VS. CONSTANTS

When all is said and done, a variable is simply a property (and its associated values) according to which objects of study are expected to differ.

We also use properties and their values to group objects into classes whose members are *alike* in certain ways. This is useful in defining what (or who) the objects of an investigation are. Thus, a researcher might limit a study to female school principals, using the principals' gender as a criterion for selecting subjects. In

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such a study, gender would be a constant, not a variable. Everyone would be alike with respect to the property. Another researcher might select school principals without regard to gender but use gender as one of the variables for investigation. In short the same property may be used as a variable in one study and as a defining attribute, hence a constant, in another. What is and is not a variable depends on the study.

In the context of a particular study, a "variable" with only one value is not a variable at all.

VARIABLES AND THE MEASUREMENT OF VARIABLES

Sometimes the properties in which researchers are interested can be measured simply and directly. A principal's gender normally can be ascertained with little difficulty, by observation in a face-to-face situation or by asking respondents to check the appropriate box on a questionnaire. The same is true for height and eye color.

Other properties of interest, though, are not immediately accessible to the senses and require a more elaborate (and potentially fallible) measurement process. Properties remote from the plane of immediate observation commonly are called *constructs*. "Amount of knowledge of school law" is a fairly abstract property, as is "level of self-esteem," and certainly neither can be determined by a quick glance. Rather, one has to assemble pieces of information from which an inference can be drawn about the principal's legal knowledge, perhaps using a set of pointed questions designed to reveal it.

By listening to, or seeing, the principal's responses, the measurement procedure converts an otherwise hidden property into observable form. But it has its price. A construct and the pieces of information from which inferences are made regarding an object's standing on it are not in one-to-one correspondence. A principal's score on a 15-item test is only a rough approximation, at best, of his or her "amount of knowledge of school law." Considerable slippage can occur between the conceptual meaning of a variable and the procedures used in trying to measure it, an issue researchers address under the rubric "validity of a measure."

When researchers attempt to specify what they mean by a property and its variations, they are providing what is called a *conceptual*, or *constitutive*, *definition* of the variable. When they describe the procedures used to measure the property, they are furnishing an *operational definition* of it.

The two are not the same, and it behooves the novice researcher not to mistake the latter for the former.

THE MODE OF VARIATION

There are two fundamental ways in which objects can differ from one another: in *kind* and in *degree*. Which of the two modes of variation is at stake in the variables of a study has wide ramifications for the conduct of research, ranging from the phrasing of hypotheses through measurement procedures to the manner of analyzing data and reporting results. It is imperative that you recognize the difference between the two.

VARIATION IN KIND

The set of values associated with variations in kind are like pigeon-holes, arranged in no particular order. Each pigeon-hole has a name or brief description of what gets stuffed into it. They do not fall along any continuum or underlying dimension. In fact, if you were to make a list of the values, you could put them in any order you chose. (But see my comments on "ordered categories" on page 10.) Following are illustrations of variations in kind, listing first the property and then the values that might be implied.

- Leadership style: autocratic, democratic, laissez-faire
- Personality disorder: schizophrenic, manic-depressive, paranoic
- Marital status: single, married, separated, divorced, widowed
- Region of country: Northeast, Midwest, South, Far West
- Opinion regarding school closure: favor, oppose, indifferent
- Orientation to profession: place-bound, career-bound
- College graduate: graduate, not a graduate

As the illustrations indicate, the property may involve several values or only two. But there always must be at least two.

It should also be clear, if you go back through the list, that the name of the property alone doesn't often give you a sure clue as to what the values are going to be. A property like "gender" does give a clue (at least among humans), since one is either male or female. A property such as "leadership style," however, is equivocal. There are a number of alternative systems for classifying leadership styles (nomothetic, ideographic, transactional, for example, or power-augmentive vs. power reductive), and unless the values were spelled out one would not know which set was involved. The same is true for the other illustrations in the list. There are other ways of categorizing marital status, region of the country, and so forth.

The lesson is that, when dealing with a variation in kind, it is essential that you explicitly enumerate the implicated values.

VARIATION IN DEGREE

Variables whose mode of variation is in degree imply an array of values that are ordered along a continuum or dimension. The values are actual numerical values indicating how far along the dimension an object lies; they are not just names of categories. Here are some illustrations:

- Level of job satisfaction
- School size
- Length of membership on school board
- Annual salary
- Aggressiveness
- Extent of centralization of decision making
- Intelligence quotient
- Pupil-teacher ratio

For the most part, the properties rather clearly point to the fact that they involve a quantitative measure, at least as I have named them. Some contain clue-words, such as "level," "length," "extent," "quotient," "ratio," and "amount." Others, like school size or annual salary, conventionally imply an array of numerical values (number of pupils, dollar amounts) and are readily recognized as variations in degree.

On the other hand, the variable name may not obviously indicate a variation in degree or may not make plain the underlying dimension along which the values are arranged. Thus, had I named the third illustration above "school board membership," you would not know for sure that it represented a variation in degree. Here's another example. "Teacher communication with colleagues" might refer to the *number* of colleagues with whom a teacher talks on a daily basis, ranging, say, from 0 to 15, or it could refer to the reported *frequency* of the teacher's conversations with colleagues, expressed perhaps on a weekly basis and ranging from 0 to 15 to 20 times a week. Either would reflect a variation in degree, but the variable's dimension is rather different in the two cases, and the variable name alone would not indicate which was at stake.

Another issue associated with variations in degree concerns the meaning to be attached to small and large numerical values, or scores. Which direction do the operationally derived scores run? Ordinarily, big numbers mean that the objects of study have a lot of the property in question, but this is not always the case. (More on this shortly.)

PRESENT-ABSENT: A SPECIAL CASE OF KIND

You will sometimes encounter variables in which the property is either present or absent. I have included some of these in the preceding illustrations of variations in kind. A principal is or is not afflicted with ulcers. A community citizen is or is not a college graduate. Other examples: a classroom does or does not have a teacher aide assigned to it, a subject in a medical study is or is not administered an experimental drug, an elementary school has or has not adopted modern math, a newspaper editorial does or does not deal with school issues. All are instances of a mode of variation in kind consisting of just two values. The properties in question are "ulcers," "college graduate," "teacher aide," "drug administration," "adoption of modern math," and "mention of school issues," and they are either present or absent for a member of the class of objects under study.

My point in discussing present-absent variations is that you may not recognize them as variables when you encounter them. The variable may be given the name of the property that is present, leaving it to your intuition to realize that the second value of the variable is the property's absence.

Putting this in the form I used earlier, the property and its values would look like this, with the implied value in parentheses:

Ulcers: ulcers, (no ulcers)

College graduate: graduate, (not a graduate)

Teacher aide: teacher aide, (no teacher aide)

Textbooks in research methods often refer to variables in this way, mainly because it makes the illustrations simpler, but variables in the present-absent mode, with their unspoken "absent" value, harbor trouble.

They might be mistaken for constants—a specification of the objects of study—rather than variables. For another thing, it is not always clear what the absent state is. Are college graduates to be contrasted with college students who have not yet graduated, with technical-school graduates, with other adults who never finished college, or with whom? The absent condition, in this way, may be a "waste-basket category" containing a great mix of objects that do not happen to meet a particular criterion for inclusion in the "present" state.

The lesson is as before: when dealing with a variation in kind, including one in the present-absent mode, explicitly enumerate the values; don't leave them to intuition.

ORDERED CATEGORIES: A HYBRID VARIETY

"Ordered categories" is an in-between mode of variation that might be used as a variation in kind or as a variation in degree in a given study. (It might even be used both ways.)

Ordered categories are unlike variations in kind discussed above in that the values of the property do, in fact, fall in a logical order. Even though the variable may be treated as a variation in kind in the analysis section of a study, each category reflects "more" of some property than the next category. The set of categories is arrayed along a distinct dimension and, in this way, looks more like a variation in degree than in kind.

For example, the values of a variable called "social-class membership" [of school patrons] might be labelled (a) "working," (b) "middle," (c) "upper-middle," and (d) "elite," obviously reflecting increasing levels of social status. Two more examples. The values associated with a variable called "principal's efforts in backing teachers" may have categories named (a) "poor," (b) "average," (c) "good," and (d) "outstanding." They clearly fall along a continuum. Teacher "homework assignment practice" may consist of these categories: (a) "never assigns homework," (b) "occasionally," (c) "frequently," or (d) "always assigns homework." Again, the values reflect varying frequencies of assignment.

Should you regard these as variations in kind or in degree? It all hinges on how the data are handled in the study. If the values are maintained as discrete categories in the analysis and report of findings, regard the variable as varying in kind. Note, though, that the investigator may choose to give numerical values to the categories and literally treat the variable as a variation in degree. He or she might assign a score of 1 to the "working-class" category, 2 to the "middle-class" category, 3 to the "upper-middle" category, and 4 to the "elite" category and proceed to calculate mean social status scores for subgroups of school patrons. (Calculation of a mean for a variable should tip you off immediately that its mode of variation is not in kind; see the following chapter.)

ANALYZING VARIABLES IN EMPIRICAL STUDIES

To understand variables, you need to read research articles in your field. Single out the key variables of a study and analyze each one separately. (You may discover that this practice helps you understand better the study itself.)

Virtually every study you encounter will have a good many variables in it—maybe only 4 or 5 but perhaps 20 or more. The variables normally are not of equal standing; later I will have more to say about how variables stand with respect to one another. For now, though, it is enough to single out for purposes of analysis the ones that are central in the study.

DESCRIBING A VARIABLE COMPLETELY

Variables can be slippery, slinky, and sly, but they have to be unravelled if you are to see how they work in research. Just giving them names doesn't tell you much about them. A full description of a variable used in a study usually requires you to examine words the author employs to say what the variable means and to inspect how it was actually measured or manipulated and used in data analysis.

There are three sections of a research report where you should look to do the unravelling. Opening sections of the report often include discussions of the key variables, what they mean, how they have been used in other studies, and the like. (If you are lucky, the author may provide carefully developed formal definitions.) You will need to look in the section on "Method" to find how the variable was measured in the context of the study. The tables contained in the "Results" section may turn out to furnish the best information about the nature of the variable. (Read the next chapter of this treatise concerning Relationships between Variables to get help in knowing what to look for in the tables.)

A variable is fully unravelled when you do the following four things:

1. Name the property, or attribute, at stake. This is equivalent to naming the variable itself. What is the property that differentiates one object (person, event, etc.) from another?
2. Indicate the objects to which the property attaches.
3. Declare its mode of variation. You have two choices: kind or degree.
4. Elaborate on the mode of variation. (This does *not* mean giving details of how the variable was measured.)
   a. If you declare the mode of variation as kind, then list all the specific categories, or values, that are involved. Give them alphabetical letters (and, for purposes of clarity, list them directly under one another).
   b. If you declare the mode of variation as degree, indicate clearly the underlying dimension or continuum. Also indicate the direction the numerical values run. It is usually sufficient to say something like "low to high X" or "little to much X," where X is a brief characterization of the dimension.

   Care in naming the property may forestall the need for extended elaboration. Sometimes you face a trade-off between using a short, convenient name for the variable and extending its description in the elaboration or squeezing all the information into the name itself and minimizing the elaboration.

To be systematic about it, lay all this out on a dissection table. Use a separate form, such as shown in table 1, for each variable you analyze.

Table 1. Dissection Table for Variables

Objects:	[To whom or what does the property apply?]
Property:	[Name of the property.]
Mode of Variation:	[Kind or degree?]
Elaboration:	[List the categories or describe the dimension.]

Your description of the variable should stand on its own feet when you are done. If you were to show it to others unfamiliar with the study, they should be able to understand it.

Incidentally, use your common sense at this point to designate the objects of study. When we get to chapter 4, particularly the discussion of the "unit of analysis" in a study (a closely related topic), you will discover that especially troublesome problems wiggle out of the woodwork.

In table 2, I give two illustrations of the dissection table at work.

Table 2. Two Examples of the Variable Dissection Table at Work

Object:	Public school superintendents
Property:	Orientation to the superintendency
Mode of Variation:	Kind
Elaboration:	a. Place bound b. Career bound
Object:	Elementary school teachers
Property:	Sense of work autonomy
Mode of Variation:	Degree
Elaboration:	Low to high feeling of classroom autonomy

SOME POTENTIAL PROBLEMS IN UNRAVELLING VARIABLES

The task of spotting and analyzing variables in empirical studies is not terribly difficult when you get the hang of it, but you are bound to run into problems and oddities. Authors of research pieces are not always precise, and there are many intricacies and technicalities that might escape you until you have gained some practice. I will mention a few things here that seem to make life hard for novices as they get into the business of analyzing variables of a study.

The first two have to do with singling out variables. Obviously, you must be able to spot one in order to analyze it, and it is not always easy to decide where one ends and another begins.

1. VARIABLE VERSUS A CLASS OF VARIABLES

An author reporting a study containing a number of variables may classify them under several headings: variables relating to "student motivation," those relating to "student-teacher interaction," those concerning "school characteristics," and so forth. A common mistake is to think that the name for a *class* of variables is itself a variable.

Also, merely because a group of variables is measured with the same "instrument" does not mean that a single variable is at hand. The Leader Behavior Description Questionnaire is a case in point. The LBDQ XII, as it is called, is a 100-item form that is designed to measure 12 distinct dimensions of a leader's behavior, such as Tolerance of Uncertainty, Persuasiveness, Initiation of Structure, Production Emphasis, Superior Orientation, and so forth. Each of the dimensions represents a separate variable whose mode of variation is in degree.

This instrument does not offer an overall measure of "leader behavior" that varies along a diagnosible dimension. (See the next problem, below.)

A good way to figure out what the distinct variables of a study are is to examine the tables presenting the study results. What do they suggest the author considered the variables to be? Even if the author is muddy in his or her exposition in the text, the tables often tell the tale.

2. SCORES, SUBSCORES, AND ITEMS

Whereas the preceding situation might induce you to count too few variables in a study, a reverse situation may lead you to count too many. The measure of a variable is often constructed from a number of separate items or indicators to yield a single score, and it would be incorrect to declare each of the items to be a variable. Attitude and personality scales and academic achievement tests are classic examples; scores are summed from alternative responses to a number of items. An index of a family's "socioeconomic status" might be formed by combining in a certain way measures of the occupation, the educational attainment, and the income of the breadwinner(s). Here there is one variable, not three. "Satisfaction with services" in a study of the clients of a placement office might be calculated from the numerical difference between ratings of the amount of help the client expected and the amount of help he or she received. "Expected help" and "received help" would not be separate variables in the study, unless they were also used independently of the "satisfaction" variable.

As long as a single score or index is derived and used as such in data analyses, treat it as a single variable. Again, examination of the tables can help.

Matters can get a bit complicated, though. Achievement tests based on multiple items often yield subscores as well as overall scores. Job satisfaction measures may be calculated similarly: satisfaction with supervision, with salary and wages, with colleague relations, with work facilities, etc., as well as "general satisfaction" (a sum of the other varieties). Authors of research articles sometimes feel impelled to analyze and report all scores and subscores within their grasp. When do you stop counting and unravelling variables under such circumstances? Let common sense be your guide.

3. "CHANGE," "IMPROVEMENT," AND "GAIN"

Now and then you will find allusions to a variable such as "attitude *change* " or "*improvement in* performance" or "achievement *gain*."

To avoid trouble, treat the variable as "attitude," not "attitude change," or "performance," not "improvement in performance."

Why? Ordinarily, words like change, improvement, and gain involve situations in which a variable has been measured at two points in time; scores on the variable at Time 2 are subtracted from scores at Time 1 to yield a numerical value indicating the amount of change (positive or negative) in the property between the two times. Thus, one property (variable) is measured twice. There are occasional exceptions when "change" literally means change, but you are normally better off analyzing the variable as though it had been measured just once and dropping any reference to "change."

4. INVENTING NAMES FOR VARIABLES

When you name the property, or variable, you should remain as faithful as possible to the words the author uses in the research report. It does not always happen, though, that the author furnishes a nice, tidy name for a variable, and it may be up to you to invent one. This occurs most often for variables that vary in kind. The author may list a set of specific values but not give a generic name to the property.

For example, a researcher might report a study comparing, say, teaching styles in: (a) secretarial schools, (b) nursing programs in community colleges, and (c) civics courses in Catholic secondary schools, obviously a variation in kind. But kind of what? How do you name the general property of which the three are particular values, especially if the author does not suggest one? The best you could do in your analysis is to give the variable an innocuous name, like "type of setting," and rely on the list of categories to describe its meaning. (Make a mental note to avoid the author's mistake in your own research.)

5. OBJECTS OF STUDY ARE NOT VARIABLES

A variable is a property that attaches to the objects of study and provides a basis for distinguishing between them. An occasional error of novices is to believe they have named a variable when they have only named the objects. If academic deans of large American universities were the objects of investigation, it would be incorrect to name a variable "deans." The variable(s), rather, would be some property or properties used in the study with regard to which the deans differ, for example, their frequency of interaction with faculty members (in degree) or the disciplinary field from which they stemmed (in kind).

6. THE CONVERSION OF VARIATION IN DEGREE TO VARIATION IN KIND

A variable with all the earmarks of a variation in degree may actually be treated in the analysis as a variation in kind. "School size" might be a case in point. Although the researcher may have in hand the student enrollments for a set of schools—values ranging from 50 to 1,000, for instance—he or she may decide to use some convenient cutoff points to classify them as "small," "medium," and "large" for purposes of data analysis. A potential variation in degree is reduced to one in kind (i.e., ordered categories).

Respondent age might seem, on the surface, to be a variation in degree, but to facilitate responses on a questionnaire the researcher might have asked respondents to check the age-range within which they fall (20-24, 25-29, 30-34, etc.). Again, this is a variation in kind rather than degree.

In general, it is always possible to reduce a variable measured in degree to a variation in kind, but you can't go the other direction. A variable measured as a set of categories cannot be elevated to a variation in degree.

7. COLLAPSING THE CATEGORIES OF A VARIATION IN KIND

A rather common practice in dealing with variables in kind is to combine, or "collapse," categories in the course of data analysis. The five-year age categories in the preceding illustration could readily be collapsed into ten-year categories or, even further, into just two values.

Consider another illustration. In a measure of occupational values, respondents are asked to select one of ten things that they regard as the most important criterion of "an ideal job or occupation"—things such as "provide a chance to earn a good deal of money," "provide an opportunity to be helpful to others," "enable me to look forward to a secure future," and "permit me to be creative and original." For purpose of analysis, the ten categories are collapsed to four: people-oriented values, extrinsic rewards, self-expression, and other values.

When you dissect such a variable, do so in light of the categories actually used in the analysis, not those that potentially could have been used.

8. WHEN SMALLER NUMBERS MEAN A BIGGER QUANTITY

At some point in the measurement process, the researcher assigns numerical values or scores to variables that vary in degree. He or she usually arranges that the larger quantities or levels of the property in question be represented by bigger numbers and that smaller quantities or lower levels be represented by smaller numbers. For some variables the numerical values and the "direction" of the variable have a natural correspondence. For "school size," larger enrollments mean greater size, and for "salary level," more dollars mean higher salaries.

Things do not always work out this nicely, though. In the game of golf, for instance, better golfers are the ones with *lower* scores, and faster runners are the ones who cover a distance in *shorter* times. So it is in measuring variables. "Amount of knowledge about school law" conceivably could be measured as the number of *wrong* answers on a 40-item test, with the result that low numbers mean a lot of knowledge and big numbers mean little knowledge. Employees' feelings of "alienation from work" may be measured so that the larger the score, the less the alienation.

The lesson: watch out! As you analyze variables that vary in degree, double check to make sure the numbers run in the direction one would expect them to from the name of the variable. If they don't, either rename the variable or make the underlying dimension clear in your elaboration of the mode of variation.

9. BI-POLAR VARIABLES

Some variations in degree are considered as ranging between a high level of one extreme to a high level of another extreme, with the extremes regarded as direct opposites of each other. Distinct names are given to each extreme value, or "pole," of the dimension. An illustration will give you the idea. The Pupil Control Ideology scale (or PCI) is designed to measure teacher views regarding the classroom control of pupils along a continuum ranging from highly "humanistic" views to highly "custodial" views of control. Inventors of the scale stipulate that "custodial" views are to be regarded as the opposite of "humanistic" views. Scoring instructions for the instrument provide numerical values ranging from 20 to 100, with larger numbers indicating greater "custodialness" and smaller numbers indicating greater "humanisticness." Teachers can be located anywhere between the two poles.

Such a variable poses several hazards. You might mistake the variable as varying in kind (the two kinds being "humanistic" or "custodial"). You might think there are two variables at stake (degree of "humanisticness" and degree of "custodialness"). What do you name the variable in order to properly describe the dimension? (In this instance, the dimension usually is called "custodialness of view" because, according to the scoring procedures, larger numbers represent higher levels of custodialism.) Since the assignment of numerical values, or scores, to a bi-polar dimension is arbitrary, you need to be especially alert to the particular direction the scores run.

HOW VARIABLES ARE USED IN EMPIRICAL STUDIES

Almost no study you read will be limited to just one variable. More likely you will find that researchers collect data on four or five or ten (and sometimes many more) variables in a given study. What in the world do you do with them? It depends, of course, on the investigator's point of doing the study in the first place. The purposes behind research can be of many sorts, but it is possible to separate empirical studies into two major piles by considering whether the researcher's interest is in the variables in their own right—in reporting how the objects of study stand on them one at a time—or whether the concern is with *causal relationships* between the variables.

The hypothesis, the main subject of this treatise, is a prediction about relationships between variables. Hence, our attention will be confined in succeeding chapters to studies in the second pile, where the intent of research is to develop or test hypotheses and where relationships assume center stage. (Different names are attached to this form of research, and no common agreement exists. I tend to favor "verificational studies.") Before moving on, it may be useful to look briefly at studies in the first pile.

A study's intent may be simply to describe a population with respect to one or more variables. Cause-effect relations are neither hypothesized nor examined. Investigations of this variety go under such names as descriptive surveys (or just plain surveys), status studies, polls, or censuses; "descriptive studies" is a sufficiently general designation. The number of variables measured in the population (or a sample of the population) may be vary large, or the measurement may be directed toward just a few variables, perhaps only one. Examples are legion.

- A study may seek to establish client satisfaction with several aspects of a university placement office for purposes of identifying the services needing improvement. Each aspect on which clients are queried regarding their level of satisfaction represents a variable.

- A research team may measure the incidence of sex-bias in a sampling of a school district's American history textbooks, using several different indicators of bias. One indicator (or variable), for instance, could be the ratio of female to male figures referenced in the textbook—the smaller the ratio, the greater the bias.

- A study may seek to describe the trend in dropout rates of a state university's freshman class over a five-year period.

- A public opinion poll may measure citizen views on a number of current issues or voting preferences in several line-ups of potential political candidates.

- The business manager of a community college may use a standard checklist to rate the adequacy of physical facilities in the classroom buildings on campus. The checklist may provide a scheme for calculating an overall score for each building as well as subscores for separate categories (space, lighting, climate control, and so forth).

The list of illustrations could go on and on and on. They share the characteristic that the variables measured in the studies are important in their own right—they are free-standing, so to speak—and that the researchers or investigating agencies exhibit little interest in establishing relationships between the variables, and certainly not causal relationships. The business manager, for instance, is uninterested in testing if buildings with more adequate space tend also to be buildings with more adequate lighting.

Ordinarily, it is fairly easy to figure out from its flow whether a study is of the descriptive or verificational sort. The manner in which the data are presented, in the tables or in the text, can help to nail this decision down. Two things can cloud the matter a bit, though. For one thing, true verificational studies often contain tables or other information describing in some detail the sample on which the study was conducted, especially in an early part of the report. The heart of the study, however, is in a later part where relationships are displayed.

For another thing, reports of descriptive studies may contain tabulations for special groupings or subpopulations of the objects of study. Such tables are formally equivalent to the examination of relationships. For instance, the incidence of sex bias may be reported separately for texts of different publishers, or candidate preferences may be reported by geographical region. The university's dropout rate may be tabulated separately according to whether or not the freshmen were in-state or out-of-state students. The purpose of the cross-tabulations is not so much to examine relationships among variables (and certainly not to test causal relations) as it is to provide more detailed descriptions of the population.

Descriptive information is enormously important to policy makers and others in all sectors of modern society, as witnessed by the vast resources devoted to its collection. The information runs the gamut from the decennial census of the population, through the Dow-Jones averages, to statistics on baseball player performance and the Guiness Book of Records.

Serious descriptive research is equally as demanding of disciplined inquiry as verificational studies, and the requisite methodological tools are similar in the two. Descriptive studies, though, place a premium on the accuracy and relevance of measurement and on the techniques of population sampling; knowledge of elaborate statistical procedures and of the ins and outs of research design have less bearing. The researcher who undertakes a descriptive study must, above all, be clear about his or her purposes, meaning particularly how the information is to be used.

CONCLUDING NOTE

There is more to know about variables. In particular, there are a number of adjectives attached to the word *variable* that designate a variable's function in a study. I'll talk about independent and dependent variables, control variables, intervening variables, and the like in the next chapter. For now, though, you have enough tools in your kit to begin disassembling the variables in empirical studies and to understand what makes them tick. Take it from me, a strong grasp of the nature of variables is a foundation for virtually every topic in research methods. It is up to you to hone your skills in spotting and unravelling them.

CHAPTER 3

RELATIONSHIPS BETWEEN VARIABLES

STUDIES THAT BRING EMPIRICAL evidence to bear on hypotheses do so by examining relationships between variables. It is useful to understand how this is done, and the present chapter offers initial guidance in a topic that can quickly get obscure. Also, such studies often deal with quite a few variables at a time. Trying to dope out what they are for and how they enter into the inspection of relationships can be a difficult task without a scheme for sorting through them. In the chapter, I will:

- Explain the three basic ways of examining relationships between two variables. The one that is applicable depends on the modes of variation of the two variables.

- Introduce you to a bunch of terms that help to classify variables and to see their standing with respect to one another.

THE GENERAL IDEA

A relationship between two variables means that, for some set of objects of interest, their standing with respect to one variable tends to correspond with their standing on the second. In the American adult population, for instance, age tends to be related to economic conservatism. Specifically, persons who are older on the age variable tend to have higher values on the conservatism variable (assuming the conservatism values run from low to high). The number of cigarettes smoked daily is related to the likelihood of contracting lung cancer. Exposure to TV violence (vs. no exposure) is said to be related to aggressive behavior among children.

Association, *covariation*, and *concomitant variation* have the same meaning as *relationship*. So does the term *correlation* (although it also has a technical meaning used to describe a particular kind of relationship, as noted shortly).

A relationship is always between just two variables. It is impossible to examine the relationship of three variables, except by doing it a pair at a time.

Two things must be true in order to examine the relationship between variables in a study. First, each object under investigation must have been measured or otherwise assigned a value on both variables. And second, there must be some variation among the objects on each variable. If all the objects have the same value on one or both variables, the variable becomes a constant insofar as the study is concerned, and the relationship cannot be determined.

HOLDING OTHER VARIABLES CONSTANT

A good bit of the business in contemporary research is devoted to the examination of relationships between pairs of variables while "controlling for," or "holding constant," one or more other variables. Ridding a study of extraneous conditions that could affect results in unwanted ways is a perpetual concern in conducting research, and it comes under discussion at various places in a course on research methods. Care in choosing objects of study in the first place, in arranging parallel conditions of investigation, and in using standard data-taking methods are among the considerations.

An important and very common procedure is the use of "statistical controls" during data analysis, through techniques known as *multivariate analysis*. Their use adds complexity to the task of examining relationships and understanding what is going on in a study, and eventually you will need to know about them. For now, though, we will limit our attention to simple (or *bivariate*) relationships between variables.

EXAMINING RELATIONSHIPS VERSUS TESTING SIGNIFICANCE

Two branches of that hairy subject known as statistics get interwoven in the inspection of relationships between variables. The branches are *descriptive* and *inferential* statistics. The descriptive branch involves little more than counting things, calculating percentages, and figuring means (averages). The most complicated thing you run into is the calculation of a correlation coefficient. Generally speaking, it is possible to comprehend the notion of relationships without getting into the other branch, though in practice the two are intertwined.

Inferential statistics concerns the question of whether the difference in percentages or means that you figure, or the numerical size of the correlation coefficient you compute, is greater than could be expected by chance. *This* is where statistics begins to get deep, and I will barely touch on the matter here.

EXAMINING SIMPLE RELATIONSHIPS

Although the technical trappings of inferential statistics may disguise the fact, there are only three basic ways of examining the relationship between a pair of variables. The three depend on the modes of variation of the implicated variables.

CASE 1: BOTH VARIABLES IN KIND

Procedure: compare percentages in a percentage table.

A percentage table actually is derived from another table—a cross-tabulation or, technically, a "contingency table." *Contingency table* is a fancy name for an everyday sort of table with which you are familiar. It is constructed by counting the number of objects in the categories of one variable that fall in the categories of the second. For instance, if one of the variables were gender (male, female) and the other were opinion regarding the school budget (for, against, undecided), the contingency table would contain the number of males found to be for, against, and undecided and the number of females who are for, against, and undecided. Entries in the cells of a contingency table are simply counts of the cases, as table 3 illustrates.

Table 3: A Sample Contingency Table

Gender	*For*	*Against*	*Undecided*	*Total*
Male	30	61	22	113
Female	81	92	28	201
Total	111	153	50	314

It is not always easy to see relationships in a contingency table merely by looking at the numbers, especially if the numbers are large and the totals are unevenly divided, as in the present case.

Table 4: A Sample Percentage Table

Gender	*For*	*Against*	*Undecided*	*Total*
Male	27%	54	19	100%
Female	40%	46	14	100%
Both	35%	48	16	100%

For this reason, the numbers typically are converted into percentages. Table 4 shows the same information expressed as the percentages of males and the percentages of females in the three opinion categories. (The only tricky part of the procedure is in deciding whether to base the percentages on the row totals, as in the present case, or the column totals; either way will work, but one way may make relationships easier to see than the other.)

A relationship exists when the percentages are not the same between the rows (if the percentages are calculated in that direction). The relationship in this example suggests that males are more likely to be against the school budget or undecided than females, who are more likely to be for it.

CASE 2: ONE VARIABLE IN KIND AND ONE IN DEGREE

Procedure: compare the means in a table of means.

When a variable is measured in degree, it is possible to compute a mean (average) for the objects measured on it. A table of means simply shows the averages for the objects in each of the several categories of the kind variable. If one were interested in the relationship between favorability toward the school budget and gender and if favorability had been measured on a scale from 1 to 10, for example, one would construct a table showing the mean favorability of the males and the mean favorability of the females. The outcome is demonstrated in table 5.

Table 5: A Sample Table of Means

Gender	*(N)*	*Mean Favorability*
Male	(113)	4.87
Female	(201)	6.50
Both	(314)	5.91

Note: The N's in parentheses indicate the number of cases on which the means are calculated.

A relationship exists when the objects in the categories of the kind variable have different means on the degree variable. Here the relationship is such that females have higher favorability values, on the average, than males.

CASE 3: BOTH VARIABLES IN DEGREE

Procedure: calculate a correlation coefficient and contemplate it.

For instance, one might calculate the correlation between respondent age and favorability toward the budget (measured in degree).

Thanks to the mysteries of algebra, it is possible to come up with a number, with a potential range from -1.00 to +1.00, that describes the relationship (negative or positive) between two variables measured in degree. A positive coefficient indicates that the larger the objects' values on one variable, the larger their values are likely to be on the other variable (a *direct* relationship). A negative coefficient indicates that the larger the values are on one variable, the lower their values are likely to be on the other (an *inverse* relationship). A coefficient of zero means that no relationship exists between the variables.

Although there are other varieties, the correlation coefficient usually calculated is the "Pearson product-moment correlation." In fact, it is the one so often used that, unless explicitly stated otherwise, you can take it for granted that a correlation coefficient is the product-moment correlation.

Its calculation begins by copying down, in two columns, the pair of values for each case. (Call the values of the age variable X and those for the favorability variable Y for the time being.) So if you have 314 cases, then 314 values of X should be paired with 314 values of Y.

Make three more columns: one for the square of each X value, one for the square of each Y value, and the last for the "cross-product," or X times Y. Now get out your adding machine (or abacus, if you prefer) and add up the columns. You should end with five sums: of the X s and Y s (SX and SY), of their squares (QX and QY), and of the cross-products (XY). Along with the number of cases (N), you are ready to plug them into a formula.

The formula:

$$r = \frac{N \times XY - SX \times SY}{\sqrt{(N \times QX - SX^2) \times (N \times QY - SY^2)}}$$

All of this is work when you have a lot of cases. Some hand calculators do most, if not all, the arithmetic for you; you need only punch in the pairs of values, and the squaring, multiplying, and adding is done automatically—maybe even the results of the formula. Still, it isn't easy.

A correlation coefficient:

$r = -.23$

There it is. The data have been reduced from a table to just a number. Now there's no need to compare three pairs of percentages or a couple of means. One number says it all: the older the respondent, the less favorable he or she is likely to be toward the school budget.

A *scattergram* provides a visual representation of the relationship between variables in degree. It is constructed by drawing a horizontal axis for values of one variable and a vertical axis for values of the other and plotting where each object of the study is located. It reveals a good bit about the relationship that you can't see by staring at a number.

SORTING OUT THE VARIABLES IN A STUDY

A majority of the published studies you read go beyond the report of simple bivariate relationships to examine relationships between two variables, holding constant one or more other variables in the process. As I said earlier, this increases the study's complexity and adds to the difficulty of doping out what is going on in it. An introductory course in statistics offers considerable help, but a second course often is necessary to get a firm grasp on a study's analysis procedures. (Occasionally, even that is not enough.) But don't fret too much. There are ways of bringing order out of apparent disorder and, at least, enabling you to discern when the statistical analyses are truly beyond your current level of understanding.

A big help, in studies involving a number of variables and their relationships, is to have a way of sorting out the variables in terms of their standing with respect to one another. The following paragraphs provide some terms that aid in the sorting process and lay a foundation for considering how multivariate relationships are examined.

INDEPENDENT AND DEPENDENT VARIABLES

The point behind many, if not most, empirical studies in behavioral research is to ferret out causal relationships. What accounts for teacher burnout? What are the various conditions that affect voter turnout in school district budget elections? How do you explain the decline in Scholastic Aptitude Test scores over the recent decades? What are the effects of TV viewing on children's acceptance of sex stereotypes? Does team teaching lead to all the good things its advocates claim for it? Why do private schools produce greater academic achievement among youngsters than public schools, if indeed they do? Our private and professional worlds are full of questions of this order, questions that entail our thinking about the causes or the consequences of things. One of the principal purposes of research is to check out tentative answers to them.

This being the case, we are furnished with an important basis for distinguishing among sets of variables in research. In studies concerned with causal relationships, there will be one or more *independent* variables and one or more *dependent* variables. Dependent variables are those regarded by the researcher as "effects," "consequences," or "outcomes"—the variation that the researcher wants to explain. *Independent* variables, then, are the tentative "causes," "determinants," or "predictors"—the factors the researcher proposes as explanations.

A reasonably standard means of depicting a causal relationship between two variables (or, better, what a researcher proposes as a causal relationship) makes use of a one-headed arrow pointing from the independent variable(s) to the dependent variable(s):

$$X \longrightarrow Y$$

And, ordinarily in a diagram, the "direction" of causality is shown as flowing from left to right. Independent variables are on the left, dependent variables on the right. Two-headed arrows commonly are used to represent relationships of a noncausal nature between a pair of variables.

Be aware that the distinction between independent and dependent variables is not inherent in the variables themselves but depends on the study. Thus, the principal's leadership style may be used as the dependent variable in one study (affected by, say, the years of administrative experience) and as the independent variable in another (affecting, say, the organizational commitment of teachers).

Also be clear that, when a relationship is established between pairs of variables in a study, nothing in the tables nor the correlation coefficient tells you which is cause and which is effect. (This is captured in the old saw, "correlation does not prove causation.") It is quite possible that an observed relationship is due to the common association of the two variables with a third, outside variable not taken into account. Under some circumstances, depending on the research design employed in a study, it may be equally plausible to argue that causation runs in the opposite direction. Notions of cause and effect are imputed to the variables by the researcher. They are matters of inference and logic, not of empirical determination.

As you read studies, usually you can figure out which variables the author considers as causal and which he or she considers as effects. Some researchers are reluctant to lay out the causal priority of their variables for you, despite the fact that an order is implicit in the study report, so you may have to read between the lines to find it. One place they often tip their hands is at the end of the report where they talk about the implications of the study.

In any event, order begins to emerge as you inspect the several variables of study and sort them by whether they are to be regarded as independent or dependent.

CONTROL VARIABLES

In one form of empirical research, the investigator's attention is fixed on the causal relationship between a particular pair of variables, such as the effect of information overload on the stress level of administrators or the effect of voter turnout on the passage of school budget levies, and the basic question he or she wants to answer is whether or not the relationship stands up when other variables known to affect stress levels or passage of budget levies are controlled. In research of this form, the investigator may choose to measure the other variables and then hold them constant in the course of statistical analysis.

A *control variable* is a variable believed to be causally related to the dependent variable and whose effect on it, if not counteracted, might be mistaken for the effect of the independent variable. It is usually feasible to identify the control variables of a study and to separate them from the primary independent and dependent variables. You may find that relationships between the control variables and the dependent variable or among the control variables themselves are presented in tables of the study report, but these are not of central interest. Rather, the action lies in the tables showing the relationship of independent and dependent variables with the control variables held constant.

INTERVENING VARIABLES

In certain studies, a third variable comes into play not as a control variable but as an *intervening variable*. In general, an intervening variable is offered as an explanation of *how* an independent variable comes to have its effect on a dependent variable. It implies a chain of causal relationships:

X ———> IV ———> Y

Variation in X leads to variation in IV, which, in turn, leads to variation in Y. That is, the known (or discovered) effect of X on Y is presumed to operate through the intervening variable; X does not affect Y directly. For instance, a researcher interested in understanding why the presence of a teacher's aide (X) enhances the academic performance of students (Y) may propose "amount of individualized instruction" as an intervening variable (IV). The argument would run that the presence (versus absence) of a classroom aide increases the amount of individualized instruction received by students and that it is the individualized instruction that enhances student performance, not the presence of an aide *per se*. (That the aide is not expected to affect performance directly is indicated by the fact that there is no causal arrow between X and Y.)

Empirical support for the argument can be obtained by observing that the original relationship between X and Y *disappears* when IV is held constant in statistical analysis.

CAUSAL MODELS

The idea of causal chains in the preceding discussion can be extended to include more variables, longer chains, and a more elaborate set of relationships hypothesized among the variables. The set of variables and relationships is commonly called a "causal model," "path model," or "structural equation model." A perusal of research journals in the last five to ten years, especially in sociology, political science, or economics, is bound to uncover a number of illustrations.

Sorting variables by their designations as independent, dependent, control, or intervening does not work in elaborate causal models. A given variable may be all four in different facets of data analysis. Normally the variables are clearly displayed in a diagram so the reader can keep track of their standing with regard to one another. However, rather sophisticated statistical procedures are required to test whether or not the observed relationships conform to the hypothesized model, and the novice researcher should not be disconcerted by the difficulty of figuring out what is going on.

MODERATOR VARIABLES

Every so often you will hear reference to the term *moderator variable*. It takes part in what is called a "contingent" or "conditional relationship" or, more generally, an "interactive effect." (See the last section of chapter 4 for more about contingent relationships.) A moderator variable is one that is said to alter (or moderate) the relationship between an independent (X) and a dependent (Y) variable. More specifically, the *relationship* between X and Y will be different, depending on the value of the moderator variable (W). Under certain values of W an X-Y relationship will appear, but under other values of W there would be no relationship between X and Y, or even an opposite relationship.

An example will help. One popular theory of job redesign in business management proposes that an increase in the "skill variety" provided by a job will increase the "job satisfaction" of workers, but only for workers who have a strong "growth need." If a worker has little "growth need," enhancing the job's skill variety will have no effect on his or her satisfaction level. "Growth need strength" is the moderator variable here (W). In effect, the theory says that there will be a direct relationship between the extent of a job's skill variety (X) and worker satisfaction (Y) when the value of W is high but no relationship between X and Y when the value of W is low.

Statistical analyses to detect the operation of moderator variables follow the same procedures, for the most part, as those employed in holding third variables constant. The difference lies in what one looks for in a percentage table or a table of means. When the X, Y, and W variables are all in degree, though, a slightly more intricate correlational procedure is required. (From the standpoint of significance tests, the researcher looks for a statistically significant *interaction* in the analysis.)

TURNING IT AROUND: ASSESSING THE MODE OF VARIATION FROM THE DATA ANALYSES

The discussion of how one examines relationships between variables often can be turned around to unravel the nature of the variables employed in a study. After looking at a study's title and glancing through its abstract to get an idea of the key variables, I often turn directly to the tables in the "Results" section. While the following clues are not infallible, they work a lot of the time.

1. If the important tables consist of percentages, you can be reasonably sure that all variables are measured in kind.
2. If the important tables are tables of means, you have a good inkling that the dependent variable is measured in degree and that the independent variables, or most of them, vary in kind.
3. When the central tables show correlation coefficients, you can pretty well figure that all of the variables are measured in degree. (However, there is slippage here; a correlation coefficient can legitimately be calculated between an X variable in kind and a Y variable in degree if the X variable has just two values.)

In making your inspection, try to single out the important tables—the ones that establish the relationships between the key variables. An article for a research journal may contain a half-dozen or more tables, only one or two of whi actually examine relationships. The others may present preliminary information, such as characteristics of the subjects of study, details of the measures of particular variables, and so forth. Don't be shocked if you find the tables in utter disarray; not all researchers know what they are doing.

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CHAPTER 4

ANATOMY OF THE HYPOTHESIS

THIS CHAPTER IS ABOUT THE hypothesis, also known as the "conceptual," "substantive," or "working hypothesis." It is the researcher's prediction about, or expectation of, a relationship between variables. The "null hypothesis," which you may have heard about in a statistics course, is something else again, as I'll talk about later.

In its elementary form, the hypothesis consists of two variables and a specification of the relationship (normally a causal relationship) that is expected to hold between them. Attached to the end of every hypothesis is the phrase *ceteris paribus*, which is the Latin for "other things being equal." A more complex (nonelementary) form of the hypothesis implicates three variables. Since it is becoming more and more popular in research, I will discuss it at the end of the chapter. So, count on hearing about:

- How to locate and dissect hypotheses in published studies. (A specially designed dissection table is available for use.)

- How to specify the relationship expected between two variables (there are two ways, depending on whether both variables are in degree or whether one is in kind).

- What the "unit of analysis" is and the tricky problems it creates.

- Why *ceteris paribus* always dangles at the end of a causal hypothesis, even if it doesn't appear in print.

- What the "null hypothesis" is (a prediction that two variables will *not* be related beyond chance) and where it belongs in research (when a test of statistical significance is about to be run).

- What kinds of hypotheses implicate more than two variables at once.

FINDING AND DISSECTING HYPOTHESES

Hypotheses set forth early in a research project are wonderful guides for the investigator. Among other things, they point to the key terms that require conceptual definitions, provide the occasion to consider and select an appropriate research design, indicate the need for collecting data and constructing measures relevant to each of the variables, and direct the researcher through the business of collating and analyzing data so that he or she does not get lost in a maze of incidental or inconsequential issues.

FINDING HYPOTHESES

In published reports of studies, the hypotheses normally appear in the opening sections along with the line of reasoning that gave rise to them.

They represent the end product of the researcher's "conceptualization" of the problem under investigation. (They may even be listed and numbered.) And the author may allude to them again in the "Discussion" section of the report.

In perhaps one-half to three-quarters of the studies you read, though, depending on your field of interest, you won't find *any* hypotheses stated explicitly. Then it is up to you to reconstruct them. How? Read the report carefully for what the author says was the point of the study. The author's discussion of the findings or phrasing of the study conclusions may reveal what he or she had in mind. Pick out the key variables and inspect the presentation of results, including the tables, to see the relationships that were examined. Try to figure out which variables the researcher regarded as causal, which ones as effects, and which ones, if any, were used as control variables. Once you have put all this together, it is entirely possible that you won't be able to tell what expectations the researcher had about the way the relationships would come out. He or she may just have been "looking."

But if there are any implicit hypotheses lurking around in the research, the chances are good that you can uncover them and state them with a fair degree of fidelity.

A word of warning. If hypotheses *are* stated in the research report, don't count on them being in the proper form. Only a minuscule fraction of researchers have read this manual or one like it, and you are bound to find plenty of pathological specimens. The next chapter will help you spot them.

DISSECTING HYPOTHESES

Anatomically speaking, the hypothesis consists of three parts: two variables and an unequivocal statement of the relationship expected between them. By now you should have a rough understanding, at least, of the nature of variables, including their two basic modes of variation, how you describe them fully, and the distinction between independent and dependent variables.

Thus, the tools you need for dissecting hypotheses into their components are mostly in your hands.

The steps in dissecting a particular hypotheses are these:

1. Identify the two variables and sort them into independent (X) and dependent (Y).
2. Describe each variable separately, following the procedures outlined in chapter 2 (pages 8-10). When the

mode of variation is in kind, list the categories and label them Xa, Xb, Xc, etc., or Ya, Yb, etc.

3. Specify unambiguously the relationship expected between the two variables.
4. Note the unit of analysis implied or actually used.

Use the dissection table provided below for each hypothesis you take apart. In the next two sections I will explain steps 3 and 4.

Table 6. Dissection Table for Hypotheses

Hypothesis #:	*X Variable*	*Y Variable*
Variable Name:		
Mode of Variation:		
Elaboration:		
Specification of Relationship:		
Unit of Analysis:		

SPECIFYING EXPECTED RELATIONSHIPS

A hypothesis must specify precisely and unequivocally how variation among the objects under study with respect to the independent variable is expected to relate to their variation on the dependent variable. The prediction cannot dilly-dally around or leave anything to the reader's imagination. It is not sufficient to say *that* two variables are expected to be related; the hypothesis must describe exactly *how* they are expected to relate. A working hypothesis makes a definite prediction (ideally based on *a priori* reasoning), even though, at the same time, the researcher regards it as a tentative prediction.

In general, sentences that state hypotheses come in two varieties, depending on whether the mode of variation of the independent variable is in kind or in degree. The illustrations below represent one of each variety.

You might wonder why there isn't a third variety suited to situations where both variables are in kind, since the previous chapter made a big deal out of examining relationships of that sort. As we'll see shortly, in such situations a dependent variable in kind has to be jiggled around to make it sound like a variation in degree before a hypothesis can be phrased succinctly.

Following are illustrations of the wording of hypotheses, the first where the independent variable varies in kind and the second where it varies in degree.

H-1. Academic achievement will be greater among pupils taught by autocratic teachers than among pupils taught by permissive teachers, *cet. parib.*

H-2. The greater the size of a community college's instructional faculty, the greater the centralization of decision making with regard to course offerings, *cet. parib.*

Consider the structure of the two sentences. H-1 is a comparative statement: the sentence compares the values on the dependent variable, "academic achievement," expected between the two categories of the independent variable, which we might call "teaching style." The categories are "autocratic teachers" and "permissive teachers," and they represent a variation in kind. The tipoff phrase in sentences of this variety is "greater *than*" something or "less *than*" something.

The sentence in H-2 does not compare one category against another. Rather, it states that the values of one variable, "centralization of decision making," will be greater as the values of the other variable, "faculty size," are greater. In this case the independent variable is in degree. Here the tipoff is the structure, "the greater" one thing, "the greater" the other or "the greater" one thing, "the lesser" the other.

That's the heart of the matter. Next, some mechanics of specifying the relationships.

INDEPENDENT VARIABLE IN KIND (DEPENDENT IN DEGREE)

What would you write down in the dissection table after "Relationship:" for H-1? You could simply rewrite the entire sentence that states the hypothesis, but that would be a waste of time and wouldn't help in laying bare the anatomy of the hypothesis. Here are three successively more economical ways of doing the same thing. They assume you have followed instructions and have given labels of Xa and Xb to the two categories of the independent variable, "teaching style."

Relationship: Academic achievement will be greater for Xa than for Xb.

Relationship: With respect to academic achievement, Xa > Xb.

Relationship: Y: Xa > Xb.

The second and third alternatives make use of the mathematical convention of inequality signs. A > B means A is greater than B, while A < B means A is less than B. A=B means what it looks like. The third alternative is a further shortcut. Since you have already labelled "academic achievement" as Y (I hope) in sorting the variables for the upper portion of the dissection table, just make the substitution and save yourself ink. The symbol "Y:" stands for the phrase, "with respect to academic achievement."

Incidentally, these ways of symbolizing relationships are purely my own invention. If you were to express a hypothesis using all this shorthand and took it down the hall to the local expert in research methodology, he or she would have no idea of what it meant. The sole purpose of it is to help *you* keep your ideas in order.

Consider a hypothesis in which the independent variable consists of three categories:

H-3. College students will develop greater critical thinking skills in self-directed study groups than in instructor-led recitation sections, while students in lecture sections will develop the least critical thinking skill, *cet. parib.*

If we acknowledge "critical thinking skills" as the Y variable (in degree) and label the categories of the X variable as Xa "self-directed study groups," Xb "instructor-led recitation sections," and Xc "lecture sections," then the expected relationship expressed in the hypothesis can be concisely written as Y: Xa > Xb > Xc. Table 7 shows how this hypothesis appears when stretched out on the dissection table.

Suppose the reasoning regarding the way instructor-student interaction in the teaching

Table 7. Dissection of H-3

Hypothesis #: H-3	*X Variable*	*Y Variable*
Variable Name:	Instructional interaction	Critical thinking skill
Mode of Variation:	Kind	Degree
Elaboration:	Xa self-directed study group Xb instructor-led recitation Xc lecture section	Lo to hi skill level
Specification of Relationship:	Y: Xa > Xb > Xc	
Unit of Analysis:	College student	

situation is thought to affect the development of thinking skills had led to a different prediction:

H-4: College students will develop greater critical thinking skills in instructor-led recitation sections than in self-directed study groups or in lecture sections.

(I'm going to omit the *cet. parib.* qualification in the remainder of the specimens. Remember that it is always there. More will be said about this qualifying phrase on page 36.)

In this version no prediction is made between self-directed study groups and the lecture condition but only that the instructor-led recitation condition will be superior to both. This would express the prediction exactly:

Relationship: Y: Xa < Xb > Xc

The symbolization, like the hypothesis, says nothing about the Xa-Xc comparison.

It may now be more apparent why I insisted that you list and label all the relevant values, or categories, associated with variables whose mode of variation is kind. It is important to do so even if there are just two categories. It permits you to specify relationships with precision.

INDEPENDENT (AND DEPENDENT) VARIABLES IN DEGREE

Specifying relationships when both the independent and dependent variables are in degree is reasonably simple. You declare it either a "direct" or an "inverse" relationship. (This corresponds to a "positive" or "negative" correlation in statistical language.)

A *direct* relationship predicts that the greater the value of X, the greater will be the value of Y. (This is synonymous with saying the lesser the value of X, the lesser will be the value of Y.) An *inverse* relationship predicts that the greater the value of X, the lesser the value of Y (which automatically implies the lesser the X, the greater the Y). Here are some alternative phrasings:

Direct: The larger the X, the larger the Y.
As X decreases, Y decreases.
The more the X, the more the Y.

Inverse: The larger the X, the smaller the Y.
As X increases, Y decreases.
The less the X, the more the Y.

To illustrate, one of the following specimens predicts a direct relationship, while the other predicts an inverse relationship.

H-5. The more supportive a supervisor is to a teacher, the more supportive the teacher will be to his/her pupils.

H-6. The larger the school's faculty, the fewer intimate friends a teacher will have among his or her colleagues.

Placing these hypotheses on the dissection tables, you will first identify the variables, declare them in degree, and elaborate on "degree of what?" Then you need only proclaim "direct" for H-5 and "inverse" for H-6 in specifying the relationship. For Heaven's sake, don't allude to any categories, like Xa or Xb, because they don't exist when the variables are in degree.

All this is pretty straightforward. However, troubles can come in two ways. Whether a relationship is direct or inverse depends on the name you or an author uses for the variables. Consider this specimen:

H-7 The greater a citizen's sense of powerlessness in political affairs, the stronger will be his or her opposition to school-district budget referenda.

It expresses a direct relationship. It becomes an inverse relationship, though, merely by rewording one of the variables, by changing "sense of powerlessness" to "sense of power" or by changing "opposition to" to "support for." For instance:

H-8. The greater a citizen's sense of power in political affairs, the weaker will be his or her opposition to school-district budget referenda.

It's the same idea, but the expected relationship has switched.

The second trouble is closely akin to the foregoing. It has to do with the direction the numerical values that are associated with variations in degree run. (I went into this in chapter 2, page 13.) The assignment of numerical values, or the calculation of scores, is an arbitrary matter insofar as their direction is concerned, and whether big numbers mean a big amount of the property or a little amount of it is often determined more by the ease of computation than by anything else. It is possible that, in a given study, the numerical values run in a surprising direction. The following hypothesis provides the basis for an example:

H-9. The longer the time a student is exposed to math instruction, the greater will be his or her achievement in math.

Suppose, in a study testing the hypothesis, a researcher had access to information regarding student absences and used it to measure "amount of exposure to math instruction." Unless the researcher went to the trouble of subtracting days absent from the number of days in the school year, the direction of the values would no longer faithfully reflect the variable as it is presently named. Bigger numbers (more days absent) would mean smaller amounts of math instruction, and support for the hypothesis would be demonstrated by a *negative* correlation coefficient, that is, by evidence of an inverse relationship, not a positive correlation as you would otherwise anticipate.

In general, the analyst of the hypothesis must be sensitive to the direction of the numerical values in variables in the degree mode. That's why I encourage you to include a phrase like "lo to hi..." in your elaboration of them. In this day and age of computerized data processing, it is not hard for researchers, too, to lose track of the direction of scores on their measuring instruments, and once in a while they forget to include that little command in the computer program that makes them run in the intended direction. The consequences can be devastating. I know!

Before finishing the discussion of variables in degree, I'll add a word about *curvilinear* relationships. They don't arise often enough in hypothesis statements for me to dwell on them, but you should be forewarned about them. The expected relationship is neither direct nor inverse but, rather, something more exotic. A real, live example comes from research on the relationship between anxiety level and task performance. Studies have shown that as a person's anxiety increases, task performance improves—but only up to some intermediate level of anxiety. Beyond that level, increasing anxiety produces decrements in performance. Plotted on a graph with anxiety level as the horizontal axis and performance level as the vertical axis, the relationship would look like an upside-down U. The relationship is direct up to a point, then becomes inverse. There are many other shapes a curvilinear relationship might take (an exponential curve, a growth curve, etc.), but I promised not to dwell.

WHAT IF BOTH VARIABLES ARE IN KIND?

Expectations regarding the way the data will fall in a percentage or contingency table with three or more columns and three or more rows are so difficult to express (or even to think about) that researchers assiduously avoid them. It is hard to state a precise hypothesis before running out of breath in such a circumstance, since it requires specifying expected differences between nearly every pair of cells vis-a-vis every other pair of cells.

If the dependent variable consists of just two categories, however, there is a neat and commonly used trick available that makes it sound as though the kind variable were in degree. It amounts to expressing the proportion or percentage of cases expected in *one* of the categories of the dependent variable and making a prediction about differences in the percentages among categories of the independent variable. I'll use an illustration to make this more transparent.

> H-10. Teacher separations from the school district will be greater among teachers who received their training in universities than among those trained in teachers colleges.

The independent variable ("location of training") is in kind, right? Right. The dependent variable ("separation from the school district") is in degree, right? Wrong! A given teacher either separates or doesn't separate from the school district, clearly a variation in kind.

What's going on here? The sentence stating the hypothesis has a comparative structure, and it contains the tipoff phrase, "teacher separations . . . will be *greater* among," suggesting that the dependent variable is in degree. (See page 28.) What's going on is that, because the categories of the dependent variable are of an either-or variety, the percentage of "separating teachers" automatically implies the percentage of "nonseparating teachers," and it is unnecesary to mention the latter. The dependent variable now looks like a variation in degree, with values running from "low percentage separating to high percentage separating."

This is an extremely common practice in research. Actually, the hypothesis would have been clearer if it had contained a phrase like "separation rate," "incidence of separation," or "percentage of separations" instead of simply "teacher separations." That would have made the nature of the dependent variable more apparent.

It wouldn't matter much if, in dissecting a hypothesis like H-10, you were to declare the dependent variable as varying in degree. Except for one thing! The statistical treatment used for analyzing data where both variables are in kind is altogether different from the statistics for data where one of the variables is truly in degree. Contingency or percentage tables require different inferential statistics than tables of means. This is beyond the scope of the manual, but if you are seriously pursuing research, you will find out about it sooner or later. In any event, do . . . repeat, do . . . make a note on your dissection table when you find that a kind variable has been jiggled into one that sounds like one in degree.

THE UNIT OF ANALYSIS

Unit of analysis is the name we will henceforth use instead of "objects of study" to refer to the persons, things, or events that a researcher seeks to explain or understand and that represent the focus of an investigation.

Why the switch from the language of chapter 2? In explaining about variables back then, it seemed helpful to distinguish between objects and their properties, a fairly straightforward idea that could be understood without relying on technical terms. Hypotheses, though, concern linkages between variables, not variables in isolation from one another, and ambiguities or other problems arise when there is not a clear correspondence between the objects of the linked variables. Recall from chapter 3 one of the things I said must be true in order to examine relationships between variables: "each object under investigation must have been measured or otherwise assigned a value on both variables" (page 18). This implies that both variables are properties of the same object. In H-7: for instance, the two variables, "sense of powerlessness" and "strength of opposition to budget referenda," are two properties of a "citizen." This is quite uncomplicated; the unit of analysis is "the citizen." H-2 is similarly uncomplicated, though the unit of analysis is no longer a person but a larger entity: "size of instructional faculty" and "extent of centralization" are two different properties of "the community college."

Now try the following hypothesis:

H-11. The greater the amount of information contained in a graphic display, the larger the number of errors students will make in immediate recall.

Matters are not so clear. One of the variables, "amount of information," seems to be a property of a "graphic display," while "recall errors" is a property of a "student." They are not properties of the same object! What brings them together, though, is the implicit notion that students are exposed to the graphic displays (they literally see them), and in this sense the amount of information in the perceived display can be considered a property of students. Or the emphasis might be turned around. The researcher could be more interested in graphic arts than student learning and regard "the display" as the unit of analysis—displays as *seen by* students. The difference is a subtle one, but in either case, the properties would attach to the same objects.

THE N OF CASES

The number (N) of cases used in a study is closely associated with the unit of analysis. In fact, one of the surest ways of discovering what the investigator considered his or her unit of analysis is to look at the data presentations for the N on which the statistical relationships are based. The N should coincide with a count of the units.

To keep things straight as you analyze hypotheses found in actual studies, you would do well to write down the N of cases in the dissection table, following your designation of the unit of analysis. If 114 citizens were studied in connection with H-7, write N=114 after designating "the citizen" as the unit of analysis. If, in connection with H-2, the correlation between faculty size and centralization were calculated for 23 community colleges, make the N part of your record. Although we shan't go into it, the interpretation of statistical analyses depends heavily on the adequacy of the N.

LEVELS OF ANALYSIS

Some of the hairiest problems of research have to do with variables at several different hierarchical "levels." The issue concerns the proper unit of analysis. Consider H-1 again, repeated here for convenience.

> H-1. Academic achievement will be greater among pupils taught be autocratic teachers than among pupils taught by permissive teachers.

Suppose a study were conducted to test the hypothesis using two intact classrooms of 20 students each. The teacher of one is chosen for being autocratic, the teacher of the other for being permissive. (Teachers and students are at two different levels—one teacher per 20 pupils.) What is the proper unit of analysis? It would be feasible, for instance, to calculate an average achievement level for the students in each class (a procedure technically called "aggregation") and compare the means between the teachers. That would yield an N of 2, clearly too small for statistical interpretation. Or should one consider "the student" as the unit of analysis, yielding an N of 40? (It would help, of course, to include more teachers in the study, along with their students, but the issue of the proper unit of analysis would remain.)

I mention the problem without resolving it. It is a matter of considerable debate these days among educational research methodologists. Achievement scores of individual students, for instance, can be aggregated to the classroom level, to the school level, and to the district level, maybe even higher, and each of these could serve as the unit of analysis. I can only warn you that substantial issues, both substantive and statistical, are associated with the levels of aggregation and the unit of analysis.

THE INVISIBLE *CETERIS PARIBUS*

Fewer than one hypothesis in 50 that you see in the flesh will have the phrase *ceteris paribus* printed at the end, and yet, whether the author knows it or not, it is always there. One of the basic tenets of the philosophy of science is that any phenomenon has numerous causes, not just one— *the principle of multiple causation*. The Latin for "other things being equal" is the scientist's way of acknowledging the existence of other causes while focusing on one of them. Consider this hypothesis:

> H-12. Automobiles with rotary engines will get better gas mileage than automobiles with piston engines, *cet. parib.*

Here the phrase means that the hypothesis is expected to told true if all the other things that affect a car's gasoline consumption are equal, or constant. These other things might include the weight of the automobile, the amount of wear on the engine, the kind of gasoline used, the speed it is driven, and so forth. The hypothesis predicts that, with all these other factors constant, the engine design itself will be found to affect gas mileage as specified.

"Other things being equal" does not mean that the cars must be identical in every conceivable respect except for engine design. Such a condition is literally impossible to meet. Rather, the phrase means that they are alike only in ways (other than engine design) that reasonably could affect gas mileage. An investigator would hardly need to certify that the heater controls were in the exact same location, for example, or that the cars all had a fleck of paint missing from the right rear fender or that the test driver had zipped his or her jacket with precisely the same hand motion in each test. "Other things" means other *relevant* things, that is, other causes, known or unknown, of the dependent variable.

The novice researcher would do well to hang *cet. parib.* on his or her hypotheses, at least until it gets to be terribly repetitive and boring. It might serve as a reminder to give serious thought to the "other relevant things" in the objects of study and the testing conditions that might affect the dependent variable and to devise plans to keep them constant or otherwise control for them.

A NOTE ON THE NULL HYPOTHESIS

The so-called "null hypothesis" plays a distinctive role in the research process and should not be mistaken for the substantive hypothesis discussed throughout the manual. Whereas the latter makes a definitive prediction concerning the relationship between the independent and dependent variables, the null hypothesis asserts that *no relationship* will exist between them beyond that which could arise by chance.

Both of these seemingly contradictory hypotheses are involved in studies testing cause-effect relationships. The substantive hypothesis is phrased early in the research process. Ordinarily it is derived from, or it connects with, a line of reasoning about the phenomenon under investigation, and it guides the researcher, as I have mentioned, in planning and conducting the study. By embodying a definite (albeit tentative) prediction, it requires the researcher to think long and hard about alternative hypotheses and about the "other relevant things" that need to be constant in order to draw a strong inference that his or her reasoning is on the right track.

The null hypothesis, on the other hand, comes into play late in the research process, at the point where a test of statistical significance is about to be applied to the relationship observed between the variables. In the course of conducting a study, for instance, regarding the superiority of rotary engines over piston engines in gasoline consumption (H-12), there comes a time when the gas consumption of the two sets of cars has been determined under equivalent testing conditions and the relationship has been displayed in a table of means (one variable in kind and one in degree). The vital question now facing the researcher is whether the difference in the means between the two sets of cars could have arisen simply by the workings of chance or whether the difference is so large that it is unlikely to have been the product of pure chance, and a significance test is in order. Enter the null hypothesis.

Without going too deeply into the matter, suffice it to say that statistical theory allows the researcher to calculate the *probability* that the observed difference could have been a matter of chance. (Even a large difference in gas mileage between the sets of cars could arise by chance, though the probability of it happening would be very low. In general, the smaller an observed difference, the greater the probability that it occurred by chance alone.) The researcher selects a probability (or significance) leve. ... the study's beginning to use in deciding whether or not observed differences fall within the bounds of chance. The .05 level is a common criterion, meaning that any difference that could occur fewer than 5 times in 100 is unlikely to have been the product of pure chance.

The researcher then proceeds to do the calculations and to test the null hypothesis, the hypothesis that the difference was within the bounds of what he or she chose as the criterion of chance. One of two answers comes from the significance test: (1) the observed difference in gas mileage was not large enough to exceed the criterion of chance—the researcher *accepts* the null hypothesis; (2) the difference was too great to regard as due to the workings of chance—the researcher *rejects* the null hypothesis. For example, let's say the group of rotary engine cars averaged 50 miles per gallon and the group of piston engine cars averaged 40 miles per gallon. Using a .05 criterion level ($p<.05$), the null hypothesis would be accepted if calculations showed that a difference of that size could occur by chance alone more frequently than 5 times in 100. However, if calculations indicated that the difference of 10 miles per gallon would occur by chance alone fewer than 5 times in 100, the null hypothesis would be rejected.

When you get right down to the nitty-gritty of empirical research, the only thing the researcher does is to accept or reject null hypotheses. And even that is an "iffy" business, since null hypotheses are hedged with probabilities. To make things worse, the null hypothesis is rarely interesting. What the researcher is interested in is the substantive hypothesis and the correctness of the reasoning that lies behind it. Yet the null hypothesis is silent with respect to such reasoning. Rejection of the null hypothesis does not affirm the truth of the substantive hypothesis. Just because a difference was too great to be attributable to chance (at a given criterion level), the researcher does not know for certain what *did* produce the difference. The point is important enough to repeat: *Rejection of the null hypothesis does not automatically imply acceptance of the substantive hypothesis!*

So what about the substantive hypothesis? How in the world do you get back to it? You can only get back to it by way of inference. You do your best to arrange the conditions of the study to eliminate as many competing hypotheses or alternative explanations of the relationship as possible. You plan your observations so that, once the null hypothesis is rejected, the most *reasonable* interpretation is the one expressed in the substantive hypothesis. The confidence you can place in the substantive hypothesis and its underlying conceptualization depends on the strength of this inference (often referred to as the "validity of inference"). In the end, one never proves a substantive hypothesis, in the ultimate sense of proof. One only gains support for it—an increment of confidence in it.

So both substantive and null hypotheses play a part in research, the substantive hypothesis giving guidance and meaning to the entire research process and the null hypothesis appearing at the juncture when statistical tests of significance are applied to the data.

HYPOTHESES INVOLVING THREE OR MORE VARIABLES

While this chapter (and the next) deals with the elementary form of the hypothesis, involving two variables, a word is in order about more complicated forms with three or more variables.

COMBINED HYPOTHESES

The first, which for want of a better term I call a *combined hypothesis*, is not really complicated at all. It merely strings together a series of elementary hypotheses in one sentence. When two or more elementary hypotheses share a common independent (X) or dependent (Y) variable, an author may combine them for the sake of saving space or reducing redundancy.

H-13. Twelve-year-old boys who are members of the Boy Scouts are more courageous, courteous, and kind than boys who are not members of the Scouts.

"Courageousness," "courteousness," and "kindness" are three Y variables varying in degree that share the common X variable, "Boy Scout membership," present versus absent. A less facetious specimen:

H-14. Per-pupil expenditure of a school district (Y) is directly related to (1X) the assessed valuation of property in the district, (2X) the proportion of the labor force in white-collar occupations, and (3X) the concern for education among adult citizens and is inversely related to the proportion of the school-age population in church-related private schools, *cet. parib.*

Four elementary hypotheses share the same Y variable. You would expect to find a test of each of these predictions in the "Results" section of the research report, perhaps using a multiple regression technique.

In your early attempts to dissect hypotheses, you would lay them out one at a time on the dissection table.

PREDICTION OF CONTINGENT RELATIONSHIPS

Truly more complicated are hypotheses that predict *contingent relationships* between variables. They involve an X variable, a Y variable, and a "moderator" variable, as described in chapter 3, pages 23-24. Indeed, that section gave an illustration from the theory of job redesign. You should review the section, but I will run through an explanation again to firm it in mind.

It is easiest to explain the idea of contingent relationships (and, indeed, to state a hypothesis regarding them) if we consider the X and the W variable to vary in kind, although, in principle, one or both of them can vary in degree.

This complex hypothesis predicts that the relationship between X and Y will differ, depending on the particular value the objects of study have on the W variable. It says that the relationship between X and Y will be such-and-such when the W variable's value is Wa, but the relationship will be something else when the value is Wb. To make this concrete, let's pick apart the following hypothesis of a contingent relationship.

H-15. Leaders (Xa) of informal groups will be more accurate (Y) than nonleaders (Xb) in estimating the opinions of group members on issues centrally relevant to group functioning (Wa), but leaders (Xa) will not differ from nonleaders (Xb) in their accuracy of estimating the opinions of group members on issues irrelevant to group functioning (Wb).

I have tried to help you locate the variables in the web of words by symbolizing them. You may be able to find the three on your own. "Accuracy in estimating opinions of group members" would be one—the dependent variable (varying in degree). Another variable would be something like "leadership status," with the two categories of Xa "leader" and Xb "nonleader." The W variable concerns the "relevance to group functioning" of the issues on which the estimation of accuracy is made, with Wa representing "centrally relevant issues" and Wb representing "irrelevant issues." If we were to express the predicted relationships using the symbols presented earlier, they would look like this:

Relationship: Y: Xa > Xb [for Wa]
Y: Xa = Xb [for Wb]

Thus, the relationship between X and Y is expected to be "contingent" on the value of W.

The statistical procedure for testing a hypothesis of this order entails more than checking two relationships separately. From the standpoint of significance testing, it also requires a test of whether the magnitude of *relationships* differ from one another by some value greater than chance. In statistical parlance, it is called testing for an "interaction."

Following is another hypothesis predicting a contingent relationship, with the variables and their categories again highlighted in parentheses.

> H-16. High redundancy in lectures in an introductory statistics course (Xa), in contrast to low redundancy (Xb), will lead to greater retention of course content (Y) among students with weak backgrounds in math (Wa), while high redundancy in lectures (Xa) will produce less retention of course content (Y) than will low redundancy (Xb) among students with a strong math background (Wb).

In this instance, the hypothesis predicts that the redundancy variable has just the opposite effect on learning for the two kinds of student.

Contingent relationships have become increasingly prominent in behavioral and educational research in recent years. A whole line of research in the psychology of teaching, for instance, has developed around what is called the "aptitude-treatment interaction" (ATI for short)—the idea (like the one expressed in H-16) that the effectiveness of instructional techniques is contingent on the aptitudes or other attributes of the student. Social psychology has produced a number of contingency theories of leadership, proposing that the style of leadership effective in promoting group productivity when the group is composed one way will not be an effective style when the group is composed a different way. Industrial psychologists have developed theories holding that the effects of various working conditions or work settings on worker satisfaction are contingent on the basic motivations of the workers exposed to those settings. Other theories predict that people behave in certain ways when their personal attributes "match" characteristics of the situation in which they find themselves and in other ways when there is a "mismatch" between personal and situational characteristics. On inspection, such theories turn out to involve predictions of contingent relationships.

Other examples could be given, but now we must turn to pathologies of elementary hypotheses.

CHAPTER 5

PATHOLOGY OF THE HYPOTHESIS

AUTHORS OF RESEARCH REPORTS every now and again serve up sentences they say are hypotheses but aren't, at least as I have defined a proper hypothesis. It may be that the author knows perfectly well what a proper hypothesis is but doesn't worry as much as I do about stating it in the "right" way. Or it may be that the author doesn't know much about research. (Nearly 90 percent of the published research in our field, according to several estimates, represents the first and the last studies the authors will ever conduct, so you can see that most of what you read is the product of a novice.)

The crucial clinical test of a hypothesis in proper form is whether or not you can stretch it out on a dissection table and find all its parts in working order. If something is missing, you can consider it defective. The test is only valid, of course, to the degree you know your anatomy and have honed your dissection skills.

A more important reason for learning about the pathology of the hypothesis than being able to pick apart someone else's phrasings of them, I believe, is being able to phrase your own in proper fashion. Hypotheses contract sundry diseases that prevent them from growing into proper form. Improper hypotheses can prove fatal to your research project.

The diseases fall into two major classes—those that afflict variables and those that attack specifications of relationships. I'll take them up according to the following outline:

1. Malformations of the variable
    - A. Only one variable
    - B. Absence of a comparison
    - C. Unknown categories

2. Abnormalities in specifications of relationships

   A. A question only

   B. Assertion only *that* a relationship exists

   C. Assertion that *no* relationship exists

As you will see, these are not clear-cut categories. Some pathologies blend into others, and you may not be able to diagnose the root-cause of the disease by examining a clinical specimen outside its natural habitat (the study itself).

MALFORMATIONS OF THE VARIABLE

ONLY ONE VARIABLE

Statements about the distribution of a sample or population on a single variable are nonhypotheses, since a proper hypothesis necessarily involves two variables (and a relationship between them). Here's an example of a statement suffering from this complaint:

> *Statement 1.* "The most important finding of our study confirms the hypothesis that high-school civics teachers of the state rarely teach about threats to civil liberties in their local communities."

The only variable is "frequency of teaching about local threats to civil liberties." The so-called hypothesis merely alludes to the standing of the state's civic teachers on it, that is, they "rarely teach about it."

Here is another example of the same sort:

> *Statement 2.* "This research set out to test the hypothesis that American school systems are organized according to Weber's bureaucratic model."

Presumably, the investigators believed there were other organizational models for school system organization besides the "bureaucratic model." The statement asserts that a count of American systems in the several categories would show all (most? a majority?) of them in the "bureaucratic" category. Thus, it is a statement about the distribution of school systems with regard to a single variable in kind.

Two more statements also pan out as nonhypotheses because they involve only a single variable:

> *Statement 3.* "For the reasons we have cited and on the basis of previous research, we expect to find that fewer than 10 percent of high-school principals are female."

> *Statement 4.* "Nebraska school board members will mainly be in the business and professional occupations rather than in agriculture, clerical, or blue-collar occupations, if our results are in keeping with the theorizing of George Counts (1927)."

Descriptive surveys are replete with statistics describing the standing of a sample or population on each of a number of variables—means, percentages, frequency distributions, standard scores, and so forth. As valuable as such information may be, they deal with one variable at a time, and statements characterizing a population with respect to a variable are not true hypotheses.

NO COMPARISON MADE

A statement intended to be a hypothesis, involving an independent variable in kind, might allude to only one of its values, failing to mention the other value(s) against which comparison is to be made. That is to say, the statement contains a Y variable and an indication of Xa but no reference to its contrasting values, Xb, Xc, etc.

Statement 5. "Teaching teams with formally designated leaders will display less consensus in views regarding appropriate disciplinary practices to use in the classroom."

Less than what other kinds of teams? The comparison is not completed.

Statement 6. "The study tested the hypothesis that enactment of state antidiscrimination statutes during the early 1970s increased the percentage of females employed as line officers in state public service agencies."

Although the dependent variable mentions only one value of gender, that should pose no problem because the other value, "male," can be taken for granted. More troublesome is the absence of a second value for the independent variable. If "enactment of antidiscrimination statutes" is Xa, what is Xb?

The disease I'm describing here is not usually disabling. It commonly afflicts independent variables of the present-absent variety, so it is easy to figure out from a study's context that the unmentioned Xb is simply the absence of Xa. Inspection of the tables or other details of the research usually permits the clinician to doctor up the author's statement and render it a healthy specimen.

Occasionally you will discover, upon examining the study context, that a statement you thought had the more serious disease discussed under the previous heading—"only one variable"—turned out to suffer from the more rectifiable problem considered here. Look again at statement 4 on page 40. It could happen that the state in which school board members were located was a second variable, "Nebraska" being one of the categories, and that the author just failed to mention the other category, say "California." Or maybe the unmentioned comparison was between Xa "school board members" and Xb "city council members." Only a more intensive diagnosis would tell.

UNKNOWN CATEGORIES

Far more virulent than the preceding is the disease in which a name is given to the independent variable (presumably a variation in kind) but *none* of its categories is mentioned. The disease can attack the dependent variable, too, or both at once, but for simplicity's sake let us concentrate on the independent variable.

Statement 7. "The severity of discipline problems in the classroom is a product of the teacher's own personality."

The X variable, "teacher personality," is named, but what categories are involved? There are numerous ways in which personalities can be said to differ, such as ascendant versus submissive, intropunitive versus extrapunitive versus impunitive, innerdirected versus other directed, and so forth. Certain aspects of personality are even formulated as varying in degree. Need for achievement or tolerance of ambiguity are cases in point. Statement 7 affords no clue as to what the variation on the X variable is.

Failure to specify how properties are conceived to vary is so common a pathology that I will present some additional specimens, with the unelaborated variables emphasized

Statement 8. "The *religious makeup* of the community is an important factor in determining the success of school tax elections."

Statement 9. "The level of teacher morale will be correlated with the *type of control structure* observed in the school organization."

Statement 10. "The rapidity with which departmental faculties of community colleges adopt instructional innovations is determined by the *social relations* that prevail among the members."

The pathology described in the present section necessarily is compounded by the disease discussed next. Between the two, the specimens can only be regarded as terminal cases.

ABNORMALITIES IN SPECIFICATIONS OF RELATIONSHIPS

The generic pathology described under this heading is the absence of an unequivocal designation of how one variable is expected to covary with the other. The disease may attack statements in which the variables themselves are perfectly normal.

Statements that fail to make precise predictions come under three guises, and most of them are easy to spot.

QUESTION ONLY

Although questions are useful in the early stages of formulating a problem for investigation and can give rise to tentative answers posed in the form of a true hypothesis, questions alone make no predictions and, hence, are not hypotheses.

Statement 11. "Are parents better informed by letter grades or number grades on report cards?"

This statement contains no prediction, hence it's not a hypothesis. I hardly need to give more examples. The questionmark at the end of the sentence should instantly alert you.

ASSERTION ONLY THAT A RELATIONSHIP EXISTS

Statements thought to be hypotheses may declare *that* a relationship exists between two variables without specifying the nature of the relationship. They do not say whether the expected relationship is direct or inverse (if the variables were in degree) or how the dependent variable is expected to differ from one value of the independent variable to another (when the latter is in kind). Following are three specimens:

Statement 12. "Men and women will differ in their rates of processing complex auditory signals."

Statement 13. "The socioeconomic level of students in secondary schools will be related to their grade averages in vocational subjects."

Statement 14. "The number of different students whom a teacher instructs in the course of a week affects the likelihood of the teacher experiencing burnout."

Note, in the last two specimens, use of the indeterminant phrases "will be related to" or "affects." They are cues that the relationship may remain unspecified. Some other cue phrases include:

is a cause of
contributes to
has an impact on
is a function of
determines
is affected by
is a factor in

Look back at statements 7 through 10 in the preceding section. Behold that they, too, contain indeterminant phrases (as well as variables that cannot be elaborated). When such phrases are used to connect the independent and dependent variables, you can be pretty sure the statement has contracted the disease discussed in this section.

ASSERTION THAT NO RELATIONSHIP EXISTS

The null hypothesis discussed toward the end of chapter 4 is a statement predicting that no relationship, other than that expected by chance, exists between two variables. As I tried to point out, it is not the same thing as a substantive hypothesis. The disease described here most often arises when the null hypothesis is *substituted* for the substantive hypothesis.

Statement 15. "There will be no significant difference between fathers and mothers of lower-class children in the roughness of the disciplinary techniques they apply to their male children."

If null hypotheses like this were the only hypotheses offered in a study—if there were no conceptual hypotheses to supplement them—then the reader (and the researcher) would be in trouble. You would have no way of knowing what substantive hypothesis the researcher had in mind and about which he or she would like to draw inferences, in the event the null hypothesis were rejected. Researchers who limit their problem formulation to a series of null hypotheses seriously inhibit themselves in reasoning through the connections that might, and might not, be expected between variables.

Researchers most susceptible to the disease of substituting null for substantive hypotheses are novices who have been exposed to courses in statistical techniques, where the null hypothesis is emphasized, but who are unaware of the general logic of the research process within which the statistical tools are applied.

On occasion, experienced researchers will formulate hypotheses predicting that two particular variables are unrelated and their doing so would be altogether proper. It happens mainly in a well-investigated area of study using well-tested measures or experimental manipulations. It also happens in studies implicating intervening or moderator variables, contingent relationships, and the like. In the two-variable case, however, predictions of the absence of relationships are so easy to affirm with data that sophisticated researchers shy away from them. Such a hypothesis can be supported for a number of reasons that have nothing to do with the soundness of one's theories, explanations, or answers to questions. Any one of the following can lead to an empirical finding of no relationship between a pair of variables:

- insensitive measuring devices
- little variation on one or both variables
- unreliable measures

- invalid measures
- inadequate or improper research design
- errors made in recording observations
- miscoding of data
- inaccuracy in computations
- mistakes in writing a computer program
- silly variables to begin with

The more ignorant, careless, or naive the researcher, the greater the odds that he or she will find support for hypotheses that predict the absence of relationships. That is not an especially sound basis on which to ground knowledge of the world around us.

ON UNDERSTANDING VARIABLES & HYPOTHESES IN SCIENTIFIC RESEARCH

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ISBN 0-86552-115-8