Behavioral Research
THEORY, PROCEDURE, AND DESIGN

SECOND EDITION

Lawrence S. Meyers · Neal E. Grossen

Second Edition

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Behavioral Research

A Series of Books in Psychology

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Preface

to the Second Edition

Our motivation in writing an introductory text is that we feel certain concepts can be communicated in a more useful way and the material can be organized more coherently than attempted in available textbooks. Measured against that goal, we feel that the first edition was quite successful. As with any first effort, though, certain decisions as to what to include and what not to include were less than optimal. Having used this book in our own classes for several semesters and having received feedback from our students and other instructors throughout the country, we were able to pinpoint some of the weaknesses in the presentation. As a result, we were very pleased with the prospect of preparing a second edition.

Changes were made in virtually all of the existing chapters. We mention here only some of the more noticeable ones. Chapter 1 on philosophy of science has been reorganized to provide a smoother flow of the ideas. Chapter 2 on measurement has been greatly expanded. Chapter 3 on graphing has also been expanded to include a section on bar graphs and a detailed set of guidelines for constructing functional plots of data. In Chapter 4 a section has been added on applying measures of central tendency to data that the student might collect. The correlation chapter, now Chapter 6, has been brought forward and included as a part of descriptive statistics.

Chapter 7 on drawing conclusions from data has been revamped to accommodate a change in emphasis over the last five years. We indicate that the *F*-ratio resulting from the analysis of variance is really a test of the significance of the correlation between the groups and the scores. From this perspective, an experiment is performed to determine the degree of observed statistical relation underlying a phenomenon rather than determining mean differences per se. The chapters on the experiment and experimental design have been expanded and modified in line with the rationale of Chapter 7.

Chapter 15, Applied Research, now includes more testing information, sections on reliability and validity, and a description of some of the more frequently used correlational techniques. Chapter 16 on scientific communication now includes more information on library reference sources and journals and is updated to conform to the latest revision of the 1974 American Psychological Association Publication Manual. Chapter 17 is completely new, a sample experimental report with full running commentary. Appendix A-I has been completely rewritten to provide simpler computational procedures for some analysis of variance models.

Notes of thanks are due certain people. A statistical review of the manuscript provided by Leonard Marascuilo was superb in both detail and content. Not only did he catch our blatant errors, he spotted a number of subtle ones as well. To Ephraim Schechter goes our special appreciation for the most comprehensive and useful review we have ever received. Many of the improvements in content and organization are a direct result of his well thought-out input. For a last-hour content and editorial review plus her editorial assistance, we would like to thank Marilee Garretson; deadlines would have been harder to meet without her help.

Lawrence S. Meyers
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February 1978

Preface

to the First Edition

This book is intended for students taking their first behavioral research course, introducing them to the concepts, tools, and procedures applicable to the behavioral and social sciences. It is organized around the information used by a researcher from the inception of a project to its completion.

The goal of science is to achieve knowledge about the world, and research is the means to that goal. In Section I, The Beginnings of Research, we discuss the relationship of research to science and scientific knowledge.

Since the immediate task of research is to observe phenomena and collect data, we present the definition of measurement and some properties of data in Section II, The Foundation of Research.

Entering the laboratory in Section III, The Techniques of Research, we examine several scientific methodologies relevant to many diverse settings, from the natural environment, to the classroom, to the formal scientific laboratory.

Following laboratory work, it is often necessary to make statistical calculations in drawing conclusions from the data. A prior familiarity with statistics is not required. We explain some of the basic statistical principles for understanding research design; Appendix A provides a simplified description of some useful calculations for the interested student. We should emphasize, however, that our treatment is no substitute for a study of statistics.

The final step in the research project is to present a summary of findings in a standardized fashion. The writing of reports is discussed in Section IV, The Communication of Research.

We would like to express our appreciation to all those who have contributed their time and energy to this book, but we take ultimate responsibility for its contents. We are indebted to the literary executor of the late Sir Ronald A. Fisher, F.R.S., to Dr. Frank Yates, F.R.S., and to Longman Group Ltd., London, for permission to reprint Tables C, D, and F in Appendix B from their book *Statistical Tables for Biological, Agricultural and Medical Research.*

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September 1973

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SECTION I

The Beginnings of Research

For centuries man has been engaged in scientific pursuits, and the results and applications of these efforts have literally changed the world. Science in all its forms (e.g., physical, chemical, behavioral) and ramifications (e.g., technology) is a major factor in the development of western civilization. Especially during this century, science in and of itself has become the object of study; the first section of this book will serve as an example of such an inquiry.

The question "What is science?" is anything but straightforward, and because it is general it is very difficult to answer. When less general (and more answerable) questions are posed no one set of answers can be given; rather, a variety of answers, many directly antagonistic to each other, may be heard. Obviously, our analysis on the nature of science can be only one among many.

The whole research process, in all its detail and complexity, takes place in an environment of three worlds:

1. *The empirical world.* Scientists begin with the assumption that there is a world external to themselves. They further believe that it is possible to interact with this empirical world, both by producing changes in it (e.g., performing experiments) and being sensitive to (e.g., measuring) changes in it.

2. *The theoretical world.* Scientists attempt to understand and explain how the empirical world works. Understanding and explanation are achieved when a scientific theory has been developed. In the evolution of a science, it is not unusual for two or more theories to be available, where each theory provides a different understanding and set of explanations regarding the empirical world. Thus, this theoretical world can be densely populated, either with several competing theories or with one very large and detailed theory.

3. *The human world.* At the center of these two worlds are those human beings who are "doing" science. We come to know the empirical world through our senses or consciousness, and the ways in which we come to know it are determined by our theories. It is the purpose of the first chapter in this book to suggest some of the ways the empirical and theoretical worlds are combined to yield the human world, for it is in this latter world that knowledge resides.

1

The Nature of Scientific Inquiry

When you enrolled in the first research course in a behavioral science curriculum, you probably had some preconceived ideas on the nature of the scientific enterprise and the relationship of science to the activities in which you will be engaged. Science textbooks used in schools, mass media representations of what scientists do, college introductory textbooks (particularly introductory psychology books), and general cultural sophistication have supplied many of you—as well as most members of society—with a particular conception of science. It is the purpose of this chapter to summarize the acculturated view of science and then to indicate some of the basic problems inherent in such an approach.

A TRADITIONAL DESCRIPTION OF SCIENCE

The concept of science, whether physics, medicine, psychology, or any other science, brings to mind a number of images. You might think of the astronomer staring through a telescope and then writing down observations, of a biochemist looking through a microscope attempting to add to the understanding of some disease, of a psychologist observing a rat running through a maze, or of the anthropologist talking to a South Sea island native about his or her family relationships. All of these activities generate *data* (the recorded observations) for the particular scientist and serve to further our knowledge about the world in which we live. The recording of observations is, in a very general way, what we mean by measuring something, and it is in this sense that the idea of measurement is incorporated into science. The concept will be explained more fully in Chapter 2.

Many of the activities engaged in by the scientist are based on data collected during this observation period. When the observations made by one scientist are obtained by other scientists under approximately the same conditions, this observational agreement may be summarized by what is called a *factual statement.* Once a number of factual statements are developed in a science, it may appear to the scientist that certain of these may be related to one another. A statement that relates factual statements to one another is called an *empirical law.*

The ancients, for example, must have observed the activity of the moon. At some times, there was a large disk in the night sky, at other times, a large crescent was seen, at still other times, a small crescent, and finally, there were times when no portion of the moon was visible. Since these observations were repeatedly made, we have a group of factual statements. Each observation is repeated every 28 days; therefore, the observations occur in some ordered sequence. The empirical law that summarizes these ordered relations is "the lunar cycle repeats itself every 28 days." An empirical law is said to be *empirical* because it has its basis in observations (that is, factual statements that are themselves based on observation), and it is said to be *lawful* in that it summarizes a relationship of certain sets of factual statements to other sets of factual statements.

Scientists usually do not stop with the establishment of empirical laws; they search after an explanation of such laws and their explanation is obtained from a satisfactory *theory.* Philosophers of science tell us that a theory consists of two main portions: the *abstract calculus* and the *rules of correspondence.* The relationship between these portions is schematized in Fig. 1.1. The abstract calculus is basically contained in a set of statements that specify the way two or more things are related. These statements are called the *postulates* of the theory. For example, in a theory of learning in animals, one postulate might relate learning to reinforcement; elsewhere in the theory, of course, these terms would be fully defined. The postulates provide the foundation of the theory—they specify general or universal relationships, such as "A is the cause of B," where such a statement is considered to be always (universally) true. Because of the generality of the statements comprising the postulates, they need to be "translated" before they can be applied to the empirical world.

One way of translating the postulates is by means of rules of correspondence. These rules literally tell us the correspondence between the terms in the postulate and the observations that scientists make. In a learning theory, for instance, the term *learning* would be translated as a change in performance that occurs under certain conditions, the term *reinforcement*

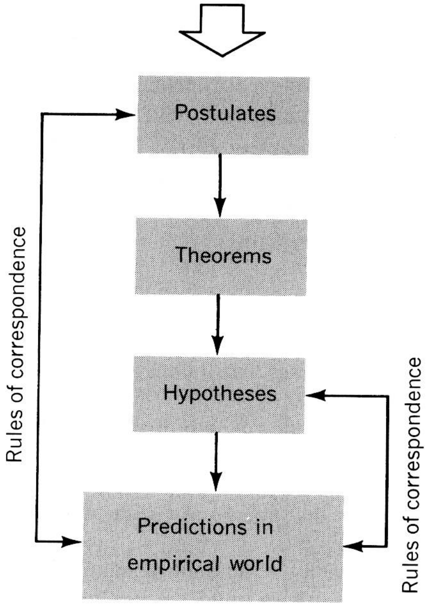

Figure 1.1 A simplified schematic of a theory.

would be an event that increases the probability of a response, and so on.

A second way of translating the postulates is to derive several *theorems* from them. Theorems are *specifications* of the postulate, relationships that must logically follow if the postulate is true. If the postulate relates learning to reinforcement, the theorem might state that the more reinforcement the animal receives, the more the animal will learn. Theorems are still universal statements, like the postulates, but they encompass a more limited domain. Thus, the theorem that more reinforcement produces more learning would be held to be universally true.

On the basis of a theorem, one can establish a hypothetical situation in which the theorem would apply. These hypothetical situations are called *hypotheses*, and permit a more concrete expression of the theorem. As an example, a hypothesis derived from our reinforcement theorem might indicate that if animals in one group are given more reinforcement than animals in another group, those getting more reinforcement will learn more. In a sense, the hypothesis sets up a test of the theorem, because if the theorem is true then the situation specified in the hypothesis should also be true. This test may then actually be carried out in the scientific laboratory.

Implementing the hypothesis requires still another step in the specification process that began back at the postulate level. In this final step, the details of the hypothetical situation are worked out. We decide how much reinforcement to give the animals in one group, how much more reinforcement to give those in the other group, what kind of learning task to use, the way in which learning will be assessed, and so forth. Each of these specifications tells us which elements in the hypothesis correspond to those in the laboratory setting. That is, the two hypothetical groups in the hypothesis now correspond to two real groups of animals, the two hypothetical quantities of reinforcement in the hypothesis now correspond to two real values, and so on. This last specification process (the implementing of the hypothesis) provides concrete *predictions* regarding the outcome of the experiment.

We can summarize the transition from the postulate to the prediction level by means of the learning theory we have been using.

Postulate: The degree of strength with which a response is associated with a stimulus (this association is called learning) is a direct function of the number of reinforcements given immediately after the responses and the magnitude of each of the reinforcements.

Theorem: All else being equal, the greater the amount of reinforcement following a response, the greater the amount of learning that will occur.

Hypothesis: If the subjects in Group A are given more reinforcement than those in Group B for comparable responses, then the subjects in Group A will learn more than those in Group B.

Prediction: The subjects in Group A will receive $r + r'$ amount of reinforcement and will take less time to solve Task X than those in Group B who will receive only r amount of reinforcement.

Note that the postulate is a general (i.e., universal) statement relating learning to reinforcement, and that the theorem considers just one specific line of reasoning from the postulate. The hypothesis is really a specification of the theorem to be studied by the scientist. We are still talking of two as yet hypothetical groups (A and B) that would receive different amounts of reinforcement. Finally, in the prediction, we see that Groups A and B will be run in an experiment, that each will be asked to learn Task X under different conditions, and that we will observe the amount of time taken by the subjects in each group to solve the task. If the prediction is correct, the scientist would probably assume that the hypothesis was likewise correct, and since the hypothesis was derived from the theory, that the theory has in this instance been verified or confirmed.

The scientist uses a theory to organize and explain a range of empirical laws and diverse factual statements. An empirical law is said to be explained when it has been made an integral part of the theory. That is, on the basis of the postulates in the theory, logical deductions or theorems are drawn. By means of the correspondence rules, a translation is made from the logical to the empirical statements. On the basis of the empirical statements, it is predicted from the theory that if such and such conditions are met, such and such should occur (be observed, measured, etc.). If the empirical events predicted are among those described by the empirical law, we can say that the theory *explains* the empirical law.

In attempting to explain the rising of the sun, for instance, the empirical law "the sun rises every 24 hours" does not explain anything; it simply