EXPERIMENTAL PSYCHOLOGY

FIFTH EDITION

METHODS OF RESEARCH

F. J. McGuigan

5th edition

Experimental Psychology

Methods of Research

F. J. McGUIGAN

United States International University
San Diego, California

PRENTICE HALL, Englewood Cliffs, New Jersey 07632

Library of Congress Cataloging-in-Publication Data

McGuigan, F. J. (Frank J.), (date)
Experimental psychology.

Includes bibliographical references and index.
1. Psychology, Experimental. 2. Psychology—Research.
I. Title.
BF181.M24 1989 150'.724 88-31721
ISBN 0-13-295023-5

Editorial/production supervision and
interior design: Joe O'Donnell
Cover design: Lundgren Graphics, Ltd.
Manufacturing buyer: Ray Keating

To two charming ladies:
Constance and Joan

A Division of Simon & Schuster
Englewood Cliffs, New Jersey 07632

Printed in the United States of America

10 9 8 7 6 5 4 3 2

ISBN 0-13-295023-5

Prentice-Hall International (UK) Limited, *London*
Prentice-Hall of Australia Pty. Limited, *Sydney*
Prentice-Hall Canada Inc., *Toronto*
Prentice-Hall Hispanoamericana, S.A., *Mexico*
Prentice-Hall of India Private Limited, *New Delhi*
Prentice-Hall of Japan, Inc., *Tokyo*
Simon & Schuster Asia Pte. Ltd., *Singapore*
Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

Experimental Psychology

Preface

PREFACE TO THE FIRST EDITION, 1960

Experimental psychology was born with the study of sensory processes; it grew as additional topics, such as perception, reaction time, attention, emotion, learning, and thinking, were added. Accordingly, the traditional course in experimental psychology was a course the content of which was accidentally defined by those lines of investigation followed by early experimenters in those fields. But times change, and so does experimental psychology. The present trend is to define experimental psychology not in terms of specific content areas, but rather as a study of scientific methodology generally and of the methods of experimentation in particular. There is considerable evidence that this trend is gaining ground rapidly.

This book has been written to meet this trend. Their methods no longer confined to but a few areas, experimental psychologists conduct research in almost the whole of psychology—clinical, industrial, social, military, and so on. To emphasize this point, we have throughout the book used examples of experiments from many fields, illustrative of many methodological points.

In short, then, the point of departure for this book is the relatively new conception of experimental psychology in terms of methodology, a conception which represents the bringing together of three somewhat distinct aspects of science: experimental methodology, statistics, and philosophy of science. We have attempted to perform a job analysis of experimental psychology, presenting the important techniques that the experimental psychologist uses every day. Experimental methods are the basis of experimental psychology, of course; the omnipresence of statistical presentations in journals attests the importance of this aspect of experimentation. An understanding of the philosophy of science is important to an understanding of what science is, how the scientific method is used, and particularly of where experimentation fits into the more general framework of scientific methodology. With an understanding of the goals and

functions of scientific methodology, the experimental psychologist is prepared to function efficiently, avoiding scientifically unsound procedures and fruitless problems.

Designed as it is to be practical in the sense of presenting information on those techniques actually used by the working experimental psychologist, it is hoped for this book that it will help maximize transference of performance from a course in experimental psychology to the type of behavior manifested by the professional experimental psychologist. My great appreciation to my students who have furnished both valuable criticisms of ideas and exposition and the reinforcement required for the completion of this project. I am also particularly indebted to Drs. Allen Calvin, Victor Denenberg, David Duncan, Paul Meehl, Michael Scriven, Kenneth Spence, and Lowell Wine.

PREFACE TO THE FIFTH EDITION

As a result of a number of suggestions from teachers and students, I have made several major changes and numerous small ones. In particular, Chapter 12, having to do with single-subject research, and Chapter 13, concerning quasi-experimental designs, have been considerably expanded. The elaboration of these two chapters is an extension of a trend started with the fourth edition, namely, that our research methodology courses are now typically of broader scope than when the book was originally written—nonexperimental and applied research is now considered to a greater extent than it used to be. In Chapters 12 and 13, additional designs have been introduced along with empirical illustrations of them. Applications of single-subject designs have become increasingly prominent in research on behavior therapy and drug evaluation, as discussed in Chapter 12.

I have also added an extensive appendix on the use of computers in psychological research, principally because of the omnipresence of the microcomputer in our research as well as in our everyday lives. Along with a historical development, the advantages and disadvantages of the uses of computers are developed.

The coverage of ethics in psychological research is also expanded in an appendix, in part in response to society's increasing concern about this topic.

Finally, I have been able to update the examples extensively throughout the book so that they more adequately reflect the nature of contemporary research. However, I did not want to discard the older examples exclusively because many remain very important and are also a significant part of our heritage.

Psychologists are in a wide variety of positions throughout society, including not only universities but business, industry, government, politics, and you-name-it. Perhaps the major reason for our success in contributing so widely to the solution of society's problems (the point of Chapter 13) is our relatively advanced knowledge and application of methods of research. The strategy of this book remains as it has through all previous editions understanding sound research and recognizing that scientific and applied research are not just not incompatible, but mutually facilitating.

Concerning the level of usage, while the book has enjoyed considerable success in undergraduate courses, it has also found a place in first-year graduate courses on research methodology. Unfortunately, the book has served far too frequently as more than just a refresher for our graduate students, indicating that sometimes we are not providing a sufficiently sound undergraduate curriculum in psychology.

Finally, I would like to express my great appreciation to Dr. Brad Davis, to Phyllis Blocki, and to Professors Randall Flory, Ronald Webster, and Frank Etscorn, whose generous suggestions improved this edition.

F. J. McGuigan

Contents

1 An Overview of Experimentation

Major purpose:	To understand the basic nature of science and its application to psychological research.
What you are going to find:	1. Essential characteristics of science discussed as steps in the scientific method. 2. The salient aspects of psychological experimentation. 3. Definitions of critical terms.
What you should acquire:	A framework for incorporating the specific phases of psychological research to be detailed in the remaining chapters.

THE NATURE OF SCIENCE

The questions that concern psychologists are singularly challenging—the great complexity of the human mind means that it will probably be the last frontier of scientific understanding. The study of psychological problems, therefore, requires the most effective research methods available. Accumulation of experience over many centuries clearly indicates that scientific methods have yielded the soundest knowledge.

Definitions

Definitions of "science" vary widely, but they can generally be categorized in two (overlapping) classes; *content* definitions and *process* definitions. A typical content definition would be that "science is an accumulation of integrated knowledge," whereas a process definition would state that "science is that activity of discovering important variables in nature, of relating those variables, and of explaining those relationships (laws)." A classical definition that incorporates content *and* processes is "science is an interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observations" (Conant, 1951, p. 25). A similar definition would be that science is "a systematically organized body of knowledge about the universe obtained by the scientific method."

Scientific and Nonscientific Disciplines

Although there may be no completely adequate definition of science, the concept set forth here will at least help us to understand and present systematically some of the basic characteristics of science. We will first consider the various sciences as a group; we can then abstract the salient characteristics that distinguish those sciences from other disciplines.

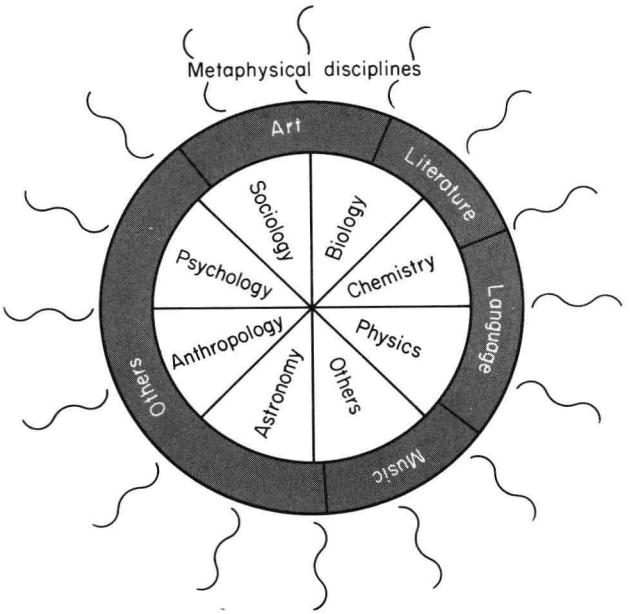

Figure 1–1 Three groups of disciplines which we study. Within the inner circle are the sciences. The second circle contains the arts and the humanities; metaphysical disciplines fall outside the circles.

Figure 1–1 is a schematic representation of the disciplines we study, crudely categorized into three groups (excluding the formal disciplines, mathematics, and logic). The sciences are represented within the inner circle. The next circle embraces disciplines not usually regarded as sciences, such as the arts and the humanities. Outside that circle are yet other disciplines which, for lack of a better term, are designated as metaphysical disciplines.

The sciences in the inner circle certainly differ among themselves in a number of ways. But in what important ways are they similar to each other? Likewise, what are the similarities among the disciplines in the outer circle? What do the metaphysical disciplines outside the circle have in common? Furthermore, in what important ways do each of these three groups differ from each other? Answers to these questions should enable us to arrive at an approximation to a general definition of science.

One common characteristic of the sciences is that they all use the same general approach in solving problems—a systematic serial process called the *scientific method.* Neither of the other two groups explicitly uses this method.

Solvable and Unsolvable Problems. The disciplines within the two circles differ from the metaphysical disciplines with regard to the type of problem studied. Individuals who study the subject matter areas within the two circles attempt to consider only problems that can be solved; those whose work falls outside the circle generally study unsolvable problems. Briefly a *solvable problem* is one that poses a question that can be answered with the use of our normal capacities. An *unsolvable problem* raises a "question" that is essentially unanswerable. Unsolvable problems usually concern supernatural phenomena or questions about ultimate causes. For example, the problem of what caused the universe is unsolvable and is typical of studies in religion and classical philosophy.[1] Ascertaining what is and what is not a solvable problem is an extremely important topic and will be taken up in detail in Chapter 2.

[1]Crude categorizations are dangerous. In pointing out general differences among the three classes of disciplines, exceptions are ignored. For example, some theological problems like the effects of prayer on the human con-

It is important to emphasize that "solvable" and "unsolvable" are technical terms so that certain vernacular meanings should not be read into them. It is not meant, for instance, to establish a hierarchy of values among the various disciplines by classifying them according to the type of problem studied. We are not necessarily saying, for example, that the problems of science are "better" or more important than are the problems of religion. The distinction is that solvable problems may be *empirically* attacked. By "empirical" we mean reliance upon observations of natural events, such as the behavior of other people. The person who attempts to solve problems through mysticism would not be using an empirical approach. Thus, solvable problems are susceptible to empirical solution by studying observable events. Unsolvable problems cannot be studied with the methods of empiricism. Individuals whose work falls within the two circles (particularly within the inner one) simply believe they must limit their study to problems that they are capable of solving. Of course, some scientists also devote part of their lives to the consideration of supernatural phenomena. But it is important to realize that when they do, they have "left the circle" and are, for that time, no longer behaving as scientists.

We must emphasize the important distinction between scientific methods for solving problems through empiricism and nonscientific methods that seek to answer questions using nonempirical approaches. There are those, for instance, who use the method of authority to answer questions ("on this issue, St. Aquinas said. . . "). Or some hold that "revelation" is a source of knowledge as when "truth" was revealed through a vision. While such nonscientific methods provide easier answers, diligent slaving over (empirical) data, tedious and demanding as it is, has been well established as our only reliable source of knowledge in the long run.

In summary, first, the sciences use the scientific method, and they study solvable problems. Second, the disciplines in the outer circle do not use the scientific method, but their problems are typically solvable. Third, the disciplines outside the circles neither use the scientific method nor do they pose solvable problems. These considerations lead to the following definition: "*Science*" *is the application of the scientific method to solvable problems.* This definition incorporates both the process (method) and the content definitions of science in that the study of solvable problems results in systematic knowledge. Generally neither of the other two groups of disciplines have *both* these features.

Psychology as a Science

The consequences of this very general definition are enormous and lead us to specify several important scientific concepts. The classical behaviorists, led by John B. Watson in the early part of the century, were instrumental in developing psychology as a science. Watson's program for a transition from a nonscience to a science was as follows: "If psychology is ever to become a science, it must follow the example of the physical sciences; it must become materialistic, mechanistic, deterministic, objective" (Heidbreder, 1933, p. 235). Watson's demand that we be *materialistic* states what is now obvious, namely, that we must study only physical events[2] like observable responses rather than ghostly "ideas" or a "consciousness" of a nonmaterial mind (see "materialism" in the Glossary). Materialism is interrelated with objectivity, for it is

---

dition *are* solvable. Studies have been conducted to determine whether praying beneficially affects patients suffering from chronic stationary or progressively deteriorating psychological or rheumatic disease (Joyce & Welldon, 1965). Although it is possible to develop at least a limited science of religion, most theologians employ methods of authority and revelation, not being interested in empirically answering their questions.

[2]Our everyday language sometimes leads us to unfortunate habits, such as the redundant term "physical events" which implies that there may be nonphysical events, a concept which staggers the imagination and which is precisely what Watson and his colleagues tried to eliminate from early psychology. The term "empirical data" is another such redundancy.

impossible to be objective when seeking to study "unobservable phenomena" (whatever that might mean). We are *objective* as a result of our application in science of a *principle of intersubjective reliability.* That is, we all have "subjective" experiences when we observe an event. "Intersubjective" means that two or more people may share the same experience. When they verbally report the same subjective experience, we conclude that the event really (reliably) occurred (was not a hallucination). In short, the data of science are public in that they are gathered objectively—scientifically observed events are reliably reported through the subjective perceptions of a number of observers, not just one. Watson's request that we be *deterministic* was not new in psychology but is critical for us. *"Determinism" is the assumption that there is lawfulness in nature.* If there is lawfulness, we are able to ascertain causes for the events that we seek to study. To the extent to which nature is nondeterministic, it is chaotic, with events occurring spontaneously (without causes). We therefore cannot discover laws for any nondeterministic phenomena, if there be such. We have, incidentally, no assurance that all events are determined. However, we must assume that those that we study are lawful if we ever hope to discover laws for them (just as the assumption that there are fish in the stream when you go fishing is a necessary condition for catching any).[3]

With these considerations and our general definition of science in hand, let us consider the scientific method as it is applied in psychology. The more abstruse and enigmatic a subject is, the more rigidly we must adhere to the scientific method and the more diligently we must control variables. Chemists work with a relatively limited set of variables, whereas psychologists must study considerably more complex phenomena. We cannot afford to be sloppy in our research. Since experimentation is the most powerful application of the scientific method, we shall focus on how we conduct experiments.

Using experiments as the ideal, we can better understand the shortcomings of the other research methods that we will also study later. The following brief discussion will provide an overview of the rest of the book. As an orientation to experimentation it will illustrate how the research psychologist proceeds. Because this overview is so brief, however, complex matters will necessarily be oversimplified. Possible distortions resulting from this oversimplification will be corrected in later chapters.

PSYCHOLOGICAL EXPERIMENTATION: AN APPLICATION OF THE SCIENTIFIC METHOD[4]

Stating the Problem

A psychological experiment starts with the formulation of a *problem,* which is usually best stated in the form of a question. The only requirement that the problem must meet is that it be solvable—the question that it raises must be answerable with the tools that are available to the psychologist. Beyond this, the problem may be concerned with any aspect of behavior, whether it is judged to be important or trivial. One lesson of history is that we must not be hasty in judging the importance of the problem on which a scientists works, for many times

[3]Watson's mechanism refers to the assumption that we behave in accordance with mechanical principles (those of physics and chemistry). But since the issue of mechanisms versus vitalism in biology was settled many decades ago in favor of mechanism, the issue is now of historic interest only, and we shall not dwell on it here.

[4]Some hold that we do not formally go through the following steps of the scientific method in conducting our research. However, a close analysis of our actual work suggests that we at least informally approximate the following pattern and, regardless, these steps are pedagogically valuable.

what was momentarily discarded as being of little importance contributed sizably to later scientific advances.

Formulating a Hypothesis

The experimenter formulates a tentative solution to the problem. This tentative solution is called a *hypothesis;* it may be a reasoned potential solution or only a vague guess, but in either case it is an empirical hypothesis in that it refers to observable phenomena. Following the statement of the hypothesis, the experimenter *tests* it to determine whether the hypothesis is (probably) true or (probably) false. If true, it solves the problem the psychologist has formulated. To test the hypothesis, we must collect *data,* for a set of data is our only criterion. Various techniques are available for data collection, but experimentation is the most powerful.

Selecting Participants

One of the first steps in collection of data is to select participants whose behavior is to be observed. The type of participant studied will be determined by the nature of the problem. If the concern is with psychotherapy, one may select a group of neurotics. A problem concerned with the function of parts of the brain would entail the use of animals (few humans volunteer to serve as participants for brain operations). Learning problems may be investigated with the use of college sophomores, chimpanzees, or rats. Whatever the type of participant, the experimenter typically assigns them to groups. We shall consider here the basic type of experiment, namely, one that involves only two groups. Incidentally, people who collaborate in an experiment for the purpose of allowing their behavior to be studied may be referred to either as *participants* or by the traditional term *subjects.* As Gillis (1976) pointed out, "participants" is socially more desirable because "subjects" suggests that people are "being used" or that there is a status difference between the experimenter and the subject (as a king and his subjects). Whether an animal should be referred to as a subject or a participant probably depends on your individual "philosophy of life." But regardless, it is important that individuals who participate in an experiment be well respected, as suggested by the use of the word "participants" in the American Psychological Association's *Ethical Principles in the Conduct of Research with Human Participants* (see Appendix D). Experimental participants should have a prestigious status, for they are critical in the advancement of our science. Other terms (e.g., "children," "students," "animals") are alternatives.

Assigning Participants to Groups

Participants should be assigned to groups in such a way that the groups will be approximately equivalent at the start of the experiment; this is accomplished through *randomization,* a term to be used extensively throughout the book. The experimenter next administers an experimental treatment to one of the groups. The experimental treatment is that which one wishes to evaluate, and it is administered to the *experimental group.* The other group, called the *control group,* usually receives a normal or standard treatment. It is important to understand clearly just what the terms "experimental" and "normal," or "standard," treatment mean.

Defining the Variables

In the study of behavior, the psychologist generally seeks to establish empirical relationships between aspects of the *environment* (the surroundings in which we live) and aspects

of behavior. These relationships are known by a variety of names, such as *hypotheses, theories,* or *laws.* Such relationships in psychology essentially state that if a certain environmental characteristic is changed, behavior of a certain type also changes.[5]

Independent and Dependent Variables. The aspect of the environment that is experimentally studied is called the *independent variable;* the resulting measure of any change in behavior is called the *dependent variable.* Roughly, a variable is anything that can change in value. It is a quality that can exhibit differences in value, usually in magnitude or strength. Thus, a *variable* generally is anything that may assume different numerical values. Anything that exists is a variable, according to E. L. Thorndike, for this promiment psychologist asserted that anything that exists, exists in some quantity. Let us briefly elaborate on the concept of a variable, after which we shall further distinguish between independent and dependent variables.

Psychological variables change in value from time to time for any given organism, between organisms, and according to various environmental conditions. Some examples of variables are the height of women, the weight of men, the speed with which a rat runs a maze, the number of trials required to learn a poem, the brightness of a light, the number of words a patient says in a psychotherapeutic interview, and the amount of pay a worker receives for performing a given task.

Figure 1–2 schematically represents one of these examples, the speed with which a rat runs a maze. It can be seen that this variable can take on any of a large number of magnitudes, or, more specifically, it can exhibit any of a large number of time values. In fact, it may "theoretically" assume any of an infinite number of such values, the least being zero seconds, and the greatest being an infinitely large amount of time. In actual situations, however, we would expect it to exhibit a value of a number of seconds or, at the most, several minutes. But the point is that there is no limit to the specific time value that it may assume, for this variable may be expressed in terms of any number of seconds, minutes, hours, including any fraction of these units.

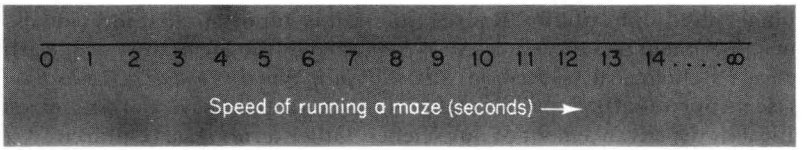

Figure 1–2 Diagrammatic representation of a continuous variable.

Continuous and Discontinuous Variables. For example, we may find that a rat ran a maze in 24 seconds, in 12.5 seconds, or in 2 minutes and 19.3 seconds. Since this variable may assume any fraction of a value (it may be represented by any point along the line in Figure 1–2), it is called a *continuous* variable. A continuous variable is one that is capable of changing by any amount, even an infinitesimally small one. A variable that is not continuous is called a *discon-*

[5]By saying that the psychologist seeks to establish relationships between environmental characteristics and aspects of behavior, we are being unduly narrow. Actually we are also concerned with processes that are not directly observed (variously called *logical constructs, intervening variables, hypothetical constructs,* and so forth). Since, however, it is unlikely that work of the young experimentalist will involve hypotheses of such an abstract nature, they will not be emphasized here. The highly arbitrary character of defining and differentiating among the various kinds of relationships should be emphasized—frequently the grossly empirical kind of relationship that we are considering under the label "hypothesis" is referred to as an empirical or observational law once it is confirmed; before it is tested, it may be referred to merely as a "hunch" or a "guess."