

EXPERIMENTAL PSYCHOLOGY

Methods of Research

Seventh Edition

F. J. McGuigan

Distinguished Research Professor

United States International University

San Diego, California

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To two charming ladies, Constance and Joan

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Preface to the Seventh Edition

This edition gave me an opportunity to carefully reread each sentence and rethink each section. As a result, there are numerous small improvements throughout the book. Of greater importance, a format change from two columns to one column will facilitate study, in large part by better presentation of statistical equations and computations. As far as statistical analysis is concerned, professors and students should realize that no previous study of statistics is assumed; that is, we commence with the computation of an arithmetic mean and proceed by explaining each step all the way through analysis of variance for factorial designs. A sample of students who have had no previous training in statistics have done as well with this book as those who have had statistical courses prior to this one.

This revision also gave me the opportunity to update a number of topics and citations and to introduce some recent studies. At the suggestion of reviewers, I have added some pedagogical aids for the student. For example, interim summaries are set in a contrasting typeface to make them easier to spot. It was also suggested that I add an appendix to introduce the student to a variety of journals in our field (Appendix E) and that I expand the ethics section (Appendix D).

In this edition I continue to emphasize the mutual facilitation of pure and applied research and the wise application of effective research methods to benefit society. Strategies for the solution of societal problems are especially developed in Chapters 10 and 11. Psychology is going through changes and is in danger of losing the methodological sophistication that has propelled it to the forefront of social and biological sciences. Psychologists are leaders in business, industry, government, politics, and academia, and their research findings on topics important for the public are cited daily in the media. However, that preeminence may erode as many psychologists neglect the study and use of sound research methodology. This book has always attempted to develop a broad perspective about where sound psychological research fits within areas of public interest as well as more generally within science. On this point some instructors whose students might be more interested in quasi-experimental research than in experimental research could assign Chapter 11 early in the course, perhaps immediately after Chapter 6, which introduces experiments.

The previous editions of this book have been widely used in undergraduate courses. However, they have also found places in graduate courses on research methodology as well as in guiding researchers in the conduct of their own work.

Finally, I want to express my great appreciation to all the colleagues who have contributed to this and previous editions of the book. In particular, reviewers for this edition were James M. Huntermark, Missouri Western State College; David L. Miller, Brown University; and Roger N. Johnson, Ramapo College. My appreciation also to Randy Flory, Andy Dollins, Anna Young, José Nededog, and especially to Patricia Moore for her outstanding assistance in many ways during the preparation of the manuscript.

*F.J.M.
San Diego, California*

Preface to the First Edition

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 Dénen-berg, David Duncan, Paul Meehl, Michael Scriven, Kenneth Spence, and Lowell Wine.

Chapter 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 is 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 of Science

People define “science” in various ways, but generally they use either **content** or **process** definitions. A typical content definition is that “science is an accumulation of integrated knowledge,” whereas a process definition is that “science is an activity of discovering important variables in nature, of relating those variables, and of explaining those relationships (which are scientific laws).” A classical definition that incorporates content and process 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 is that science is “a systematically organized body of knowledge about the universe, obtained by the scientific method.”

Scientific and Nonscientific Disciplines

Sciences Use the Scientific Method. To understand 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 is a schematic representation of the disciplines we study, crudely categorized into three groups (excluding the formal disciplines of 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 are designated as metaphysical disciplines. To understand **metaphysics**, note that the great philosopher Bertrand Russell referred to metaphysics as an attempt to conceive of the world mystically in contrast to one which urges the study of science. It is a discipline that deals with what supposedly is beyond the physical or the empirical. An instance is the Christian Science system of mental healing, of mind over body.

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? Then, what do the metaphysical disciplines outside the circle have in common? Finally, 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 of 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

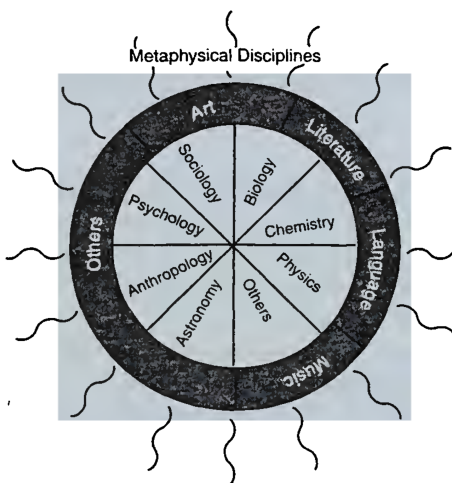


FIGURE 1-1 Three groups of disciplines that we study. Within the inner circle are the sciences. The second circle contains the arts and the humanities; metaphysical disciplines fall outside the circles.

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 unanswerable. Unsolvable problems often 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.

Science Is Empirical. It is important to emphasize that “solvable” and “unsolvable” are technical terms so that certain vernacular meanings should not be read into them. The classification 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 the problems of religion. The distinction is that solvable problems may be *empirically* attacked. By **empirical** we mean relying 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.

The distinction between scientific methods used to solve problems through empiricism and nonscientific methods used for answering questions with nonempirical approaches is important. Some, for instance, use the method of authority to answer questions (“on this issue, St. Aquinas said . . .”). Others hold that revelation reveals truth through visions. While such nonscientific methods provide easier answers, diligent slaving over (empirical) data, tedious and demanding as it may be, has been well established as our only reliable source of knowledge in the long run.

Science Defined. First, sciences apply the scientific method to 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

¹Crude categorizations are dangerous. In pointing out general differences among the three classes of disciplines, exceptions are ignored. For example, some theological problems, such as the effects of prayer on the human condition are solvable; e.g., studies have been conducted to determine whether praying beneficially affects patients suffering from various diseases. 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 answering their questions empirically.

neither use the scientific method nor pose solvable problems. Consequently we define **science** as 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 the accumulation of systematic knowledge. Generally, neither of the other two groups of disciplines has *both* of these features.

Psychology as a Science

Psychology Is Materialistic (Physicalistic), Objective, and Deterministic. The consequences of this very general definition of science 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 demands that we follow **materialism** . . . , which states what is now obvious: namely, that we must study only physical events² such as observable responses, rather than ghostly "ideas" or a "consciousness" of a nonmaterial mind. Today, however, the term **physicalistic** is preferred to materialistic because physics now studies some events that do not consist of solid material. **Physicalism** is interrelated with objectivity, for it is impossible to be objective when attempting to study unobservable phenomena (whatever that might mean). **Objectivity** in science is when we apply the **principle of intersubjective reliability**. 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

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

them (just as assuming that there are fish in the stream when you go fishing is a necessary condition for catching any).³

Behavior—The Most Complex Subject Matter. 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 thinking or research. Since experimentation is the most powerful application of the scientific method, we shall focus on how we conduct experiments.

Experimentation—The Most Powerful Research Method. 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.

Interim Summary. Psychology became a science by applying the scientific method to solvable problems which required that it become materialistic, objective, and deterministic. To accomplish this, psychology became the science of behavior.

PSYCHOLOGICAL EXPERIMENTATION: AN APPLICATION OF THE SCIENTIFIC METHOD⁴

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 scientist works, for many times what was momentarily discarded as trivial or irrelevant contributed sizably to later scientific advances.

³Watson's mechanism refers to the assumption that we behave in accordance with mechanical principles (those of physics and chemistry). But, since the issue of mechanism 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.

⁴Some 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.

Formulating a Hypothesis

The experimenter formulates a tentative solution to the problem in the form of a **hypothesis**. The hypothesis 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; i.e., stimuli and behavior. 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 collecting 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 depressives. 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, those 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**. "Participants" is preferable and recommended in *Publication Manual of the American Psychological Association*, 1994. While "subjects" is acceptable, the term 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 an individual's philosophy of life. But, regardless, it is important that those who are studied in an experiment be well respected (see Appendix D on ethics). 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 and Treatments (Conditions)

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.

Stimulus-Response Laws

In the study of behavior, the psychologist generally seeks to establish empirical relationships between **stimuli** (aspects of the external **environment**, the surroundings in which we live) and **responses** (aspects of behavior). These stimulus-response relationships, known as (S-R) laws, essentially state that if a certain environmental characteristic is changed, behavior of a certain type also changes.⁵

Independent and Dependent Variables. The stimulus event that is experimentally studied is an **independent variable**; the measure of any change in behavior is a **dependent variable**. Roughly, a **variable** is anything that can change in value or amount, such as magnitude or intensity. Thus, a variable generally is anything that may assume different numerical values. The prominent psychologist E. L. Thorndike asserted that anything that exists, exists in some quantity, so that anything that exists is a variable. The brightness of light and the amount of pay a worker receives for performing a given task are independent variables that can be changed in value. The speed with which a football player runs the length of the football field, the number of trials required to learn a poem, and the number of words a patient says in a psychotherapeutic interview are examples of dependent variables.

Figure 1-2 represents the speed of running a football field. This variable can obviously take on any of a large number of time values. In fact, it may assume any of an infinite number of such values, the least being, theoretically, zero seconds, and the greatest being an infinitely large amount of time. In actual situations, however, we would expect the variable to exhibit a value of a number of seconds. The point is that such a variable may assume any value, in terms of any number of seconds or fraction of a second; e.g., a player may run the field in 11.5, 12.7, or 18.6 seconds.

Continuous and Discontinuous Variables. Since this variable may assume any fraction of a value (it may be represented by any point along the line in Figure

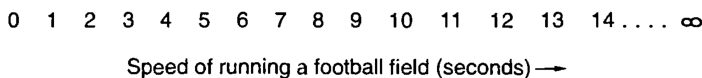


FIGURE 1-2 Representation of a continuous variable that can vary by any amount.

⁵By 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 student will involve hypotheses of such an abstract nature, they will not be elaborated here.