EIGHTH EDITION

Forty Studies That Changed Psychology

Explorations into the History of Psychological Research

Pearson

Roger R. Hock

Forty Studies That Changed Psychology

Explorations into the History of Psychological Research

Eighth Edition

Roger R. Hock, Ph.D.
Mendocino College

Pearson

Portfolio Manager: *Tanimaa Mehra*
Content Producer: *Sugandh Juneja*
Portfolio Manager Assistant: *Anna Austin*
Product Marketer: *Marianela Silvestri*
Art/Designer: *SPi Global*
Full-Service Vendor: *SPi Global*
Full-Service Project Manager: *Bhanuprakash Sherla, SPi Global*
Compositor: *SPi Global*
Printer/Binder: *LSC Communications, Inc.*
Cover Printer: *LSC Communications, Inc.*
Cover Design: *Lumina Datamatics, Inc.*
Cover Art: *wenmei Zhou/DigitalVision Vectors/Getty Images*

Library of Congress Cataloging-in-Publication Data
Names: Hock, Roger R., 1948- author.
Title: Forty studies that changed psychology: explorations into the history of psychological research / Roger R. Hock, Ph.D.
Description: Eighth edition. | Hoboken, NJ: Pearson Education, Inc., [2019]
Identifiers: LCCN 2019018574 | ISBN 9780135705063 (print)
Subjects: LCSH: Psychology—Experiments—History—20th century. | Psychology—Experiments—History—21st century.
Classification: LCC BF198.7 .H63 2019 | DDC 150.1—dc23 LC record available at https://lccn.loc.gov/2019018574

ScoutAutomatedPrintCode

Pearson

Rental Edition
ISBN-10: 0-13-570506-1
ISBN-13: 978-0-13-570506-3

Instructor's Review Copy
ISBN-10: 0-13-489763-3
ISBN-13: 978-0-13-489763-9

Brief Contents

This page intentionally left blank

Contents

Preface

Welcome to the eighth edition of *Forty Studies That Changed Psychology.* For over 25 years, this book has been a mainstay for many college and high school courses around the world and has been translated into six languages. The majority of the studies included in this edition are the same ones that made up a large part of the first edition. This demonstrates how these landmark studies continue today to exert their influence over psychological thought and research. These original studies and the ones that have been added or changed over the years provide a fascinating glimpse into the birth and growth of the *science of psychology* and into the insights we have acquired trying to unravel the complexities of human nature.

Many studies of human behavior have made remarkable and lasting impacts on the various disciplines that comprise the vast field of psychology. The findings generated from this research have changed our knowledge of human behavior, and they have set the stage for countless subsequent projects and research programs. Even when the results of some of these pivotal studies have later been drawn into controversy and question, their effect and influence in a historical context never diminish. They continue to be cited in new articles, they continue to be the topic of academic discussion, they continue to form the foundation for hundreds of textbook chapters, and they continue to hold a special place in the minds of psychologists.

The concept for this book is originated from my three decades of teaching psychology. Most psychology textbooks are based on key studies that have shaped the science of psychology over its relatively brief history. Textbooks, however, seldom give the original core studies the attention they richly deserve. The original research processes and findings often are summarized and diluted to the point that little of the life and excitement of the discoveries remain. Sometimes, research results are reported in ways that may even mislead the reader about the study's real impact and influence about what we know and how we know it. This is in no way a criticism of the textbook writers who work under length constraints and must make many difficult choices about what gets included and in how much detail. The situation is, however, unfortunate because the foundation of all of modern psychology is scientific research, and through over a century of ingenious and elegant studies, our knowledge and understanding of human behavior have been expanded and refined to the advanced level of sophistication that exists today.

This book is an attempt to fill the gap between all those psychology textbooks and the research that made them possible. It is a journey through the *headline history* of psychology. My hope is that the way the 40 chosen studies are presented will bring every one of them back to life so that you can experience them for yourself. This book is intended for anyone, in any course, who wishes a greater understanding of the true roots of psychology.

Choosing the Studies

The studies included in this book have been carefully chosen from those found in psychology texts and journals and from those suggested by leading authorities in the many branches of psychology. As the studies were selected, 40 seemed to be a realistic number both from a historical point of view and in terms of length. The studies chosen are arguably among the most famous, the most important, or the most influential in the history of psychology. I use the word *arguably* because many who read this book may wish to dispute some of the choices. One conclusion is sure: No *single* list of 40 studies would satisfy *everyone.* However, the studies included here stirred up a great deal of controversy when they were published, sparked the most subsequent related research, opened new fields of psychological exploration, changed dramatically our knowledge of human behavior, and continue to be cited frequently. These studies are organized by chapter according to the major psychology branches into which they best fit: *Biology and Human Behavior; Perception and Consciousness; Learning and Conditioning; Intelligence, Cognition, and Memory; Human Development; Emotion and Motivation; Personality; Psychopathology; Psychotherapy;* and *Social Psychology*.

Presenting the Studies

The original studies themselves are not included in their entirety in this book. Instead, I have discussed and summarized them in a consistent format throughout the book to promote a clear understanding of the studies presented. Each reading contains the following:

1. An exact, readily available reference for where the original study can be found
2. A brief introduction summarizing the background in the field leading up to the study and the reasons the researcher carried out the project
3. The theoretical propositions or hypotheses on which the research rests

4. A detailed account of the experimental design and methods used to carry out the research, including, where appropriate, who the participants were and how they were recruited; descriptions of any apparatus and materials used; and the actual procedures followed in carrying out the research
5. A summary of the results of the study in clear, understandable, nontechnical, nonstatistical, no-jargon language
6. An interpretation of the meaning of the findings based on the author's own discussion in the original article
7. The significance of the study to the field of psychology
8. A brief discussion of supportive or contradictory follow-up research findings and subsequent questioning or criticism from others in the field
9. A sampling of recent applications and citations of the study in others' articles to demonstrate its continuing influence
10. References for additional and updated readings relating to the study

Often, scientists speak in languages that are not easily understood. (Even by other scientists!) The primary goal of this book is to make these discoveries meaningful and accessible to the reader and to allow you to experience the excitement and drama of these remarkable and important discoveries. Where possible and appropriate, I have edited and simplified some of the studies presented here for ease of reading and understanding. However, this has been done carefully so that the meaning and elegance of the work are preserved and the impact of the research is distilled and clarified.

New to the Eighth Edition

This eighth edition of *Forty Studies* offers numerous noteworthy and substantive changes and additions. The *Recent Applications* sections near the end of the readings have been substantively updated. These sections sample recent citations of the 40 studies into the 21st century. The 40 studies discussed in this book are referred to in over 1,000 research articles every year! A small sampling of those articles is briefly summarized throughout this edition to allow you to experience the *ongoing* influence of each or more of these 40 studies that changed psychology. These new studies (that have cited the study under discussion) include the following (only authors and titles are included here—full reference information is available at the end of each main-study discussion):

- Alferink, L., et al., (2010). Brain-(not) based education: Dangers of misunderstanding and misapplication of neuroscience research.
- Cacioppo, S., et al., (2014). Toward a neurology of loneliness.
- Hur, Y. M., et al., (2014). Shared genetic and environmental influences on self-reported creative achievement in art and science.
- Adolph, K. E., et al., (2014). Fear of heights in infants.
- Hobson, J. (2009). REM sleep and dreaming: Towards a theory of protoconsciousness.
- Clercq, T. D. (2017). Embracing Ambiguity in the Analysis of Form in Pop/Rock Music, 1982–1991.
- Moens, E., et al., (2014). How can classical conditioning learning procedures support the taste development in toddlers.
- DeAngelis, T. (2010). Little Albert regains his identity.
- Churchill, A., et al., (2015). The creation of a superstitious belief regarding putters in a laboratory-based golfing task.
- Rubie-Davies, C. M., & Rosenthal, R. (2016). Intervening in teachers' expectations: A random effects meta-analytic approach to examining the effectiveness of an intervention.
- Tsai, Min-Ying, (2016). Research on multiple intelligences of junior high school students with different background variables.
- Moser, E., & Moser, M. B. (2014, March). Mapping your every move.
- Carlson, C. A., et al., (2017). An investigation of the weapon focus effect and the confidence–accuracy relationship for eyewitness identification.
- Berscheid, E. (2010). Love in the fourth dimension.
- Zentall, T. R., & Pattison, K. F. (2016). Now you see it, now you don't: object permanence in dogs.
- Walker, L. J. (2014). Sex differences in moral reasoning.
- Garcia, J. R., et al., (2014). Variation in orgasm occurrence by sexual orientation in a sample of US singles.
- Lawrence, K., et al., (2015). Age, gender, and puberty influence the development of facial emotion recognition.
- Philipa, R., et al., (2012). A systematic review and meta-analysis of the fMRI investigation of autism spectrum disorders.
- Frantzen, K. et al., (2016). Parental self-perception in the autism spectrum disorder literature: a systematic mixed studies review.
- Moses, I., et al., (2016). Gender and gender role differences in student–teachers' commitment to teaching.
- Denollet, J. Et al., (2010). General propensity to psychological distress affects: Cardiovascular outcomes: Evidence from research on the type D (distressed) personality profile.
- Bhandari, S. (2018). Mental health and psychotherapy: Types of psychotherapy.
- Appukutan, D. (2016). Strategies to manage patients with dental anxiety and dental phobia.

- Mondal, A., & Kumar, M. (2015). A study on Rorschach depression index in patients suffering from depression.
- Nagle, Y. K., & Rani, E. K. (2015). Sound apperception test: Development and validation.
- Carson, A. (2018). Bureau of Justice Statistics.
- Parsons, D., (2016). Social conformity to moral dilemmas.
- van Bommel, M., et al., (2016). Booze, bars, and bystander behavior: People who consumed alcohol help faster in the presence of others.
- Griggs, R. A., & Whitehead III, G. I. (2015). Coverage of Milgram's obedience experiments in social psychology textbooks: Where have all the criticisms gone?

As you read through the brief summaries of these studies, you will be able to appreciate the breadth and richness of the contributions still being made today by the 40 studies that comprise this book.

Over the several years since completing the seventh edition, I have continued to enjoy numerous conversations with, and helpful suggestions from, colleagues in many branches of psychological research about potential changes in the selection of studies over the decades of revisions of this book. This has resulted in a selection of 40 studies that represents the history of psychological research *arguably* as well as can be expected.

All the studies, regardless of vintage, discussed in the upcoming pages have one issue in common: research ethics. Perhaps the most important building block of psychological science is a strict understanding and adherence to a clear set of professional ethical guidelines in any research involving humans or animals. Let's consider briefly the ethical principles social scientists work diligently to follow as they make their discoveries.

The Ethics of Research Involving Human or Animal Participants

Without subjects, scientific research is virtually impossible. In physics, the subjects are matter and energy; in botany, they are plant life; in chemistry, they are molecules, atoms, and subatomic particles; and in psychology, the participants are people. Sometimes, certain types of research do not ethically permit the use of human participants, so animal subjects are substituted. However, the ultimate goal of animal research in psychology is to understand human behavior better, not to study the animals themselves. In this book, you will be reading about research involving both human and animal subjects. Some of the studies may cause you to question the ethics of the researchers in regard to the procedures used with the subjects.

When painful or stressful procedures are part of a study, the question of ethics is noted in the chapter. However, because this is such a volatile and topical issue, a brief discussion of the ethical guidelines followed by present-day psychologists in all research is included here in advance of the specific studies described in this book.

Research with Human Participants

The American Psychological Association (APA) has issued strict and clear guidelines that researchers must follow when carrying out experiments involving human participants. A portion of the introduction to those guidelines reads as follows:

> Psychologists strive to benefit those with whom they work and take care to do no harm. In their professional actions, psychologists seek to safeguard the welfare and rights of those with whom they interact. . . . When conflicts occur among psychologists' obligations or concerns, they attempt to resolve these conflicts in a responsible fashion that avoids or minimizes harm. . . . Psychologists uphold professional standards of conduct, clarify their professional roles and obligations, accept appropriate responsibility for their behavior, and seek to manage conflicts of interest that could lead to exploitation or harm. . . . Psychologists respect the dignity and worth of all people, and the rights of individuals to privacy, confidentiality, and self-determination (excerpted from *Ethical Principles of Psychologists and Code of Conduct*, 2003; see http://apa.org/ethics).

Researchers today take great care to adhere to those principles by following basic ethical principles in carrying out all studies involving human participants. These principles may be compiled and summarized as follows:

1. *Protection from harm.* This may seem overly obvious to you: Of course, researchers have the duty to protect their research participants from harm; don't they? The answer is yes! But this was not always a hard and fast rule. As you will see in a few of the studies in this book, debates have long ensued over whether the rights of the volunteers were violated and whether researchers truly followed the other following guidelines. Moreover, the protection must extend beyond the experiments so that if a participant has any disturbing thoughts later on, he or she may contact the researchers and discuss them.
2. *Informed consent.* A researcher must explain to potential participants what the experiment is about and what procedures will be used so that the individual is able to make an informed decision about whether or not to

participate. If the person then agrees to participate, this is called *informed consent.* As you will see in this book, sometimes the true purposes of an experiment cannot be revealed because this would alter the behavior of the participants and contaminate the results. In such cases, when deception is used, a subject still must be given adequate information for informed consent, and the portions of the experiment that are hidden must be both justifiable based on the importance of the potential findings and revealed to the participants at the end of their involvement in the study. In research involving children or minors, parent or guardian consent is required and the same ethical guidelines apply.

3. *Freedom to withdraw at any time.* Part of informed consent is the principle that all human participants in all research projects must be aware that they may withdraw freely from the study at any time. This may appear to be an unnecessary rule because it would seem obvious that any subject who is too uncomfortable with the procedures can simply leave. However, this is not always so straightforward. For example, undergraduate students are often given course credit for participating as participants in psychological experiments. If they feel that withdrawing will influence the credit they need, they may not feel free to do so. When participants are paid to participate, if they are made to feel that their completion of the experiment is a requirement for payment, this could produce an unethical inducement to avoid withdrawing if they wish to do so. To avoid this problem, participants should be given credit or paid at the beginning of the procedure *just for showing up.*
4. *Confidentiality.* All results based on participants in experiments should be kept in complete confidence unless specific agreements have been made with the participants. This does not mean that results cannot be reported and published, but this is done in such a way that individual data cannot be identified. Often, no identifying information is even acquired from participants, and all data are combined to arrive at *average* differences among groups.
5. *Debriefing.* Most psychological research involves methods that are completely harmless, both during and after the study. However, even seemingly harmless procedures can sometimes produce negative effects, such as frustration, embarrassment, or concern. One common safeguard against those effects is the ethical requirement of debriefing. After participants have completed an experiment, especially one involving any form of deception, they should be debriefed. During debriefing, the true purpose and goals of the experiment are explained to them, and they are given the opportunity to ask any questions about their experiences. If there is any possibility of lingering aftereffects from the experiment, the researchers should provide participants with contact information if participants might have any concerns in the future.

As you read through the studies included in this book, you may find a few studies that appear to have violated some of these ethical principles. Those studies were carried out long before formal ethical guidelines existed and the research could not be replicated under today's ethical principles. The lack of guidelines, however, does not excuse past researchers for abuses. Judgment of those investigators and their actions must now be made by each of us individually, and we must learn, as psychologists have, from past mistakes.

Research with Animal Subjects

One of the hottest topics of discussion inside and outside the scientific community is the question of the ethics of animal research. Animal-rights groups are growing in number and are becoming increasingly vocal and militant. More controversy exists today over animal subjects than human participants, probably because animals cannot be protected, as humans can, with informed consent, freedom to withdraw, or debriefing. In addition, the most radical animal rights activists take the view that all living things are ordered in value by their ability to sense pain. In this conceptualization, animals are equal in value to humans and, therefore, any use of animals by humans is seen as unethical. This use includes eating a chicken, wearing leather, and owning pets (which, according to some animal-rights activists, is a form of slavery).

At one end of the spectrum, many people believe that research with animals is inhumane and unethical and should be prohibited. However, nearly all scientists and most Americans believe that the limited and humane use of animals in scientific research is necessary and beneficial. Many lifesaving drugs and medical techniques have been developed through the use of animal experimental subjects. Animals have also often been subjects in psychological research to study issues such as depression, brain development, overcrowding, and learning processes. The primary reason animals are used in research is that to carry out similar research on humans clearly would be unethical. For example, suppose you wanted to study the effect on brain development and intelligence of raising infants in an enriched environment with many activities and toys, versus an impoverished environment with little to do. To assign human infants to these different conditions would simply not be possible. However, most people would agree that rats could be studied without major ethical concerns to reveal findings potentially important to humans (see Reading 2 on research by Rosenzweig and Bennett).

The APA, in addition to its guidelines on human participants, has strict rules governing research with animal subjects that are designed to ensure humane treatment. These rules require that research animals receive proper housing, feeding, cleanliness, and health care. All unnecessary pain to the animal is prohibited. A portion of the APA's *Guidelines for the Ethical Conduct in the Care and Use of Animals* (2004) reads as follows:

> Animals are to be provided with humane care and healthful conditions during their stay in the facility. . . . Psychologists are encouraged to consider enriching the environments of their laboratory animals and should keep abreast of literature on well-being and enrichment for the species with which they work. . . . When alternative behavioral procedures are available, those that minimize discomfort to the animal should be used. When using aversive conditions, psychologists should adjust the parameters of stimulation to levels that appear minimal, though compatible with the aims of the research. Psychologists are encouraged to test painful stimuli on themselves, whenever reasonable (see http://apa.org/science/anguide.html).

In this book, several studies involve animal subjects. In addition to the ethical considerations of such research, difficulties also arise in applying findings from animals to humans. These issues are discussed in this book within each reading that includes animal research. Each individual, whether a researcher or a student of psychology, must make his or her own decisions about animal research in general and the justifiability of using animal subjects in any specific instance. If you allow for the idea that animal research is acceptable under *some* circumstances, then, for each study involving animals in this book, you must decide if the value of the study's findings supports the methods used.

One final note related to this issue of animal subjects involves a development that is a response to public concerns about potential mistreatment. The city of Cambridge, Massachusetts, one of the major research centers of the world and home to institutions such as Harvard University and the Massachusetts Institute of Technology (MIT), has led the way by creating the position of *Commissioner of Laboratory Animals* within the *Cambridge Health Department* (see http://www.-cambridgepublichealth.org/services/regulatory-activities/lab-animals). This was the first such governmental position in the United States. Cambridge, and the many research universities there, is home to 44 laboratories that house over 200,000 animals. The commissioner's charge is to ensure humane and proper treatment of all animal subjects in all aspects of the research process, from the animals' living quarters to the methods used in administering the research protocols. If a lab is found to be in violation of Cambridge's strict laws concerning the humane care of lab animals, the commissioner is authorized to impose fines of up to $300 per day. As of this writing, only one such fine has been imposed; it amounted to $40,000 (for 133 days in violation) on a facility that appeared to have deliberately disregarded animal treatment laws (Dr. Julie Medley, Commissioner of Laboratory Animals, e-mail, April 15, 2012). In all other cases, any facility that has been found in violation has willingly and quickly corrected the problem. The studies you are about to experience in this book have benefited all of humankind in many ways and to varying degrees. The history of psychological research is a relatively short one, but it is brimming with the richness and excitement of discovering human nature.

Acknowledgments

I would like to express my gratitude to Ashley Dodge, editor in chief at Pearson, for her support and continuing, talented assistance on this project. For this edition, my sincere thanks go out to Tanimaa Mehra, sponsoring editor at Pearson, Sugandh Juneja, the content producer at Pearson, and Bhanuprakash Sherla, the project manager at SPi Global.

Thank you to my psychology colleagues in the field who have taken the time, interest, and effort to communicate to me their comments, suggestions, and wisdom relating to this and previous editions of *Forty Studies*. I have attempted at every opportunity to incorporate their valued insights into each edition.

To my family, my friends, and my students who have participated in the history of this book in so many tangible and intangible ways over the past 20+ years (you know who you are), I extend my continuing best wishes and heartfelt thanks.

Roger R. Hock

This page intentionally left blank

Chapter 1

Biology and Human Behavior

Learning Objectives

1.1 Summarize research on the relationship between the right and left sides of the human brain

1.2 Evaluate how Rosenzweig's research on the social environment of rats has influenced analysis and understanding of brain enrichment in humans

1.3 Explain how twin studies are used to study the impact of genetics on human behavior

1.4 Describe applications and results of experimental measurements of depth perception development

Typically, the first or second chapter in general psychology focuses on various aspects of the biology of human behavior. This is simply not due to convention but because basic biological processes, primarily dealing with the brain, underlie *all* behavior. The other branches of psychology rest, to varying degrees, on this biological foundation. The area of psychology that studies these basic physiological functions is usually called *psychobiology*, *biological psychology*, *or behavioral neuroscience*. These fields focus on the actions of your brain and nervous system, the processes of receiving stimulation and information from the environment through your senses, the ways your brain organizes sensory information to create your perceptions of the world, and how all of this affects your behavior.

The studies chosen to represent this basic component of psychological research include a wide range of research, are often cited and are among the most influential. The first study discusses a famous research program on right-brain/left-brain specialization that shaped much of our present knowledge about how the brain functions. The second study surprised the scientific community by demonstrating how a stimulating "childhood" might result in a more highly developed brain. The third study represents a fundamental change in the thinking of many psychologists about the basic causes of human behavior, personality, and social interaction—namely, an appreciation for the significance of your *genes' effect* on your behavior. The fourth study is the invention of the famous *visual cliff* method of studying infants' brains to perceive depth. All these studies, along with several others in this book, also address an issue that underlies and connects nearly all areas of psychology and provides the fuel for an ongoing and fascinating debate: the nature–nurture controversy.

Reading 1.1: One Brain or Two?

Gazzaniga, M. S. (1967). The split brain in man. *Scientific American*, *217*(2), 24–29.

1.1 Summarize research on the relationship between the right and left sides of the human brain

You are probably aware that the two halves (or *hemispheres*) of your brain are not the same and that they perform different functions. For example, in general, the left side of your brain is responsible for movement on the right side of your body, and vice versa. Beyond this, though, the two brain hemispheres have much more elaborate specialized abilities.

It has come to be rather common knowledge that for most of us, the left brain controls our ability to use language while the right is involved in spatial relationships, such as those needed for artistic activities. Stroke or head-injury patients who suffer damage to the left side of the brain will often lose, to varying degrees, their ability to speak (often this skill returns with therapy and training). Some researchers believe that each hemisphere of your brain may actually be a separate mental system with its own individual abilities for learning, remembering, perceiving the world, and feeling emotions. The concepts underlying this view of the brain rest on early scientific research on the effects of splitting the brain into two separate hemispheres.

This research was pioneered by Roger W. Sperry (1913–1994), beginning about 15 years prior to the article examined in this chapter. In his early work with animal subjects, Sperry made many remarkable discoveries. For example, in one series of studies, cats' brains were surgically altered to sever the connection between the two halves of the brain and to alter the optic nerves so that the left eye transmitted information only to the left hemisphere and the right eye only to the right hemisphere. Following surgery, the cats appeared to behave normally and exhibited virtually with no ill effects. Then, with the right eye covered, the cats learned a new behavior, such as walking through a short maze to find food. After the cats became skilled at maneuvering through the maze, the eye cover was shifted to the cats' left eyes. Now, when the cats were placed back in the maze, their right brains had no idea where to turn, and the animals had to relearn the entire maze from the beginning.

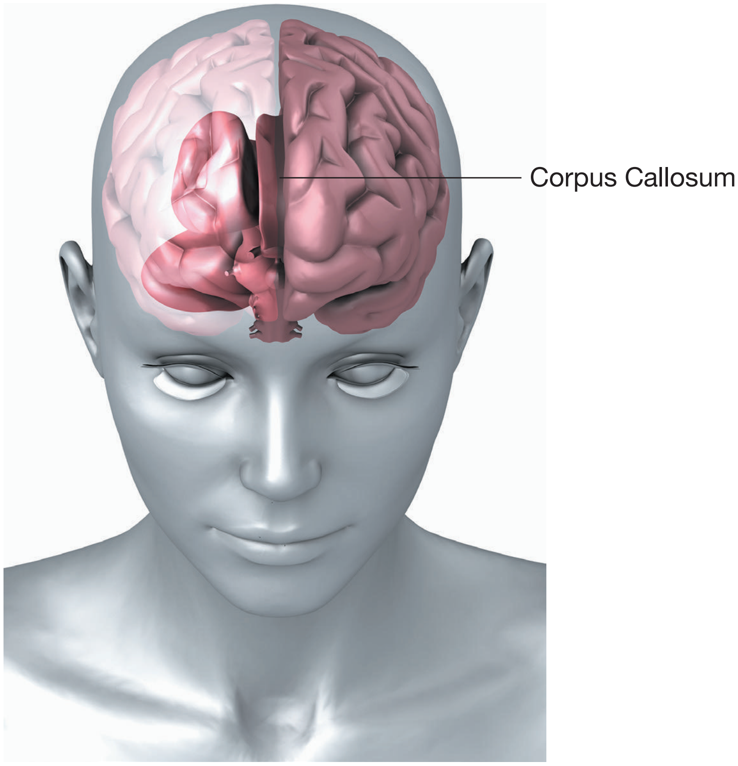
Sperry conducted many related studies over the next 30 years, and in 1981 he received the Nobel Prize for his work on the specialized abilities of the two hemispheres of the brain. When his research endeavors turned to human participants in the early 1960s, he was joined in his work at the California Institute of Technology (Caltech) by Michael Gazzaniga. Although Sperry is considered to be the founder of split-brain research, Gazzaniga's article has been chosen here because it is a clear, concise summary of their early collaborative work with human participants and it, along with other related research by Gazzaniga, is cited often in psychology texts. Its selection is in no way intended to overlook or overshadow either Sperry's leadership in this field or his great contributions. Gazzaniga owes his early research, and his discoveries in the area of hemispheric specialization, to Roger W. Sperry (see Sperry, 1968; Puente, 1995).

To understand split-brain research, some knowledge of human physiology is required. The two hemispheres of your brain are in constant communication with one another via the *corpus callosum*, a structure made up of about 200 million nerve fibers (Figure 1.1.1). If your corpus callosum is cut, this major line of communication is disrupted, and the two halves of your brain must function then independently. If we want to study each half of your brain separately, "all" we need to do is surgically sever your corpus callosum.

But can scientists surgically divide the brains of humans for research? That sounds more like something out of a Frankenstein movie than real science! Obviously, research ethics would never allow such drastic methods simply for the purpose of studying the specialized abilities of the brain's two hemispheres. However, in the late 1950s, the field of medicine provided psychologists with a golden opportunity. In some people with very rare and very extreme cases of uncontrollable epilepsy, it was found that seizures

Figure 1.1.1 The corpus callosum.

SOURCE: 3D4Medical/Science Source



could be greatly reduced or virtually eliminated by surgically severing the patient's corpus callosum. This operation was (and is) successful, as a last resort, for those patients who cannot be helped by any other means. When this article was written in 1966, 10 such operations had been undertaken, and four of the patients consented to participate in examination and testing by Sperry and Gazzaniga to determine how their perceptual and intellectual skills were affected by this surgical treatment.

Theoretical Propositions

The researchers wanted to explore the extent to which the two halves of the human brain are able to function independently as well as whether they have separate and unique abilities. If the information traveling between the two halves of your brain is interrupted, would the right side of your body suddenly be unable to coordinate with the left? If language is controlled by the left side of the brain, how would your ability to speak and understand words be affected by this surgery? Would thinking and reasoning processes exist in both halves separately? If the brain is really two separate brains, would a person be capable of functioning normally when these two brains are no longer able to communicate? Considering that we receive sensory input from both the right and the left brains, how would the senses of vision, hearing, and touch be affected? Sperry and Gazzaniga attempted to answer these and many other questions in their studies of split-brain individuals.

Method

The researchers developed three types of tests to explore a wide range of mental and perceptual capabilities of the patients. One was designed to examine visual abilities. They devised a technique that allowed a picture of an object, a word, or parts of words to be transmitted only to the visual area (called a *field*) in *either* the right or left brain hemisphere, but not to both. Normally, both of your eyes send information to both sides of your brain. However, with exact placement of items or words in front of you, and with your eyes fixed on a specific point, images can be fed to the right or the left visual field of your brain independently.

Another testing situation was designed for tactile (touch) stimulation. Participants could feel, but not see, an object, a block letter, or even a word in cutout block letters. The apparatus consisted of a screen with a space under it for the participant to reach through and touch the items without being able to see them. The visual and the tactile devices could be used simultaneously so that, for example, a picture of a pen could be projected to one side of the brain and the same object could be searched for by either hand among various objects behind the screen (see Figure 1.1.2).

Testing auditory abilities was trickier. When sound enters either of your ears, sensations are sent to both sides of your brain. Therefore, it is not possible to limit auditory input to only one side of the brain even in split-brain patients. However, it is possible to limit the *response* to such input to one brain hemisphere. Here is how this was done: Imagine that several common objects (a spoon, a pen, a marble) are placed into a cloth bag and you are then asked, verbally, to find certain items by touch. You would probably have no trouble doing so. If you place your left hand in the bag, it is being controlled by the right side of your brain, and vice versa. Do you think either side of your brain could do this task alone? As you will see in a moment, both halves of the brain are not equally capable of responding to this auditory task. What if you are not asked for specific objects but are asked to reach into the bag and identify objects by touch? Again, this would not be difficult for you, but it would be difficult for a split-brain patient.

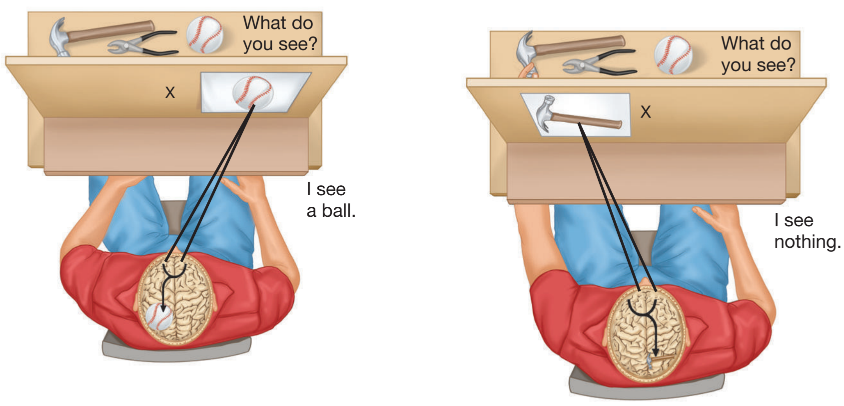
Gazzaniga combined all these testing techniques to reveal some fascinating findings about how the brain functions.

Results

First, know by following this radical brain surgery, the patients' intelligence level, personality, typical emotional reactions, and so on were relatively unchanged. They were happy and relieved that they were now free of seizures. Gazzaniga reported that one patient, while still groggy from surgery, joked that he had "a splitting headache." When testing began, however, these participants demonstrated many unusual mental abilities.

VISUAL ABILITIES One of the first tests involved a board with a horizontal row of lights. When a patient sat in front of this board and stared at a point in the middle of the lights, the bulbs would flash across both the right and left visual fields. However, when the patients were asked to explain what they saw, they said only the lights on the right side of the board had flashed. Next, when the researchers flashed only the lights on the

Figure 1.1.2 A typical visual testing device for split-brain participants.



left side of the visual field, the patients claimed to have seen nothing. A logical conclusion from these findings was that the right side of the brain was blind. Then an amazing thing happened. The lights were flashed again, only this time the patients were asked to point to the lights that had flashed. Although they had said they only saw the lights on the right, they pointed to all the lights in both visual fields. Using this method of pointing, it was found that both halves of the brain had seen the lights and were equally skilled in visual perception. The important point here is that when the patients failed to *say* that they had seen all the lights, it was not because they didn't see them but because the center for speech is located in the brain's left hemisphere. In other words, for you to say you saw something, the object has to have been seen by the left side of your brain.

TACTILE ABILITIES You can try this test yourself. Put your hands behind your back. Then have someone place familiar objects (a spoon, a pen, a book, a watch) in either your right or your left hand and see if you can identify the object. You would not find this task to be very difficult, would you? This is basically what Sperry and Gazzaniga did with the split-brain patients. When an object was placed in the right hand in such a way that the patient could not see or hear it, messages about the object would travel to the left hemisphere and the patient was able to name the object and describe it and its uses. However, when the same objects were placed in the left hand (connected to the right hemisphere), the patients could not name them or describe them in any way. But did the patients *know* in their right brain what the object was? To find out, the researchers asked the participants to match the object in their left hand (without seeing it, remember) to a group of various objects presented to them. This they could do as easily as you or I could. Again, this places verbal ability in the left hemisphere of the brain. Keep in mind that the reason you are able to name unseen objects in your left hand is that the information from the right side of your brain is transmitted via the corpus callosum to the left side, where your center for language says, "That's a spoon!"

VISUAL PLUS TACTILE TESTS Combining these two types of tests provided support for the preceding findings and also offered additional interesting results. If participants were shown a picture of an object to the right hemisphere only, they were unable to name it or describe it. In fact, they might display no verbal response at all or even deny that anything had been presented. However, if the patients were allowed to reach under the screen with their left hand (still using only the right hemisphere) and touch a selection of objects, they were always able to find the one that had been presented visually.

The right hemisphere can think about and analyze objects as well. Gazzaniga reported that when the right hemisphere was shown a picture of an item such as a cigarette, the participants could touch 10 objects behind the screen, all of which did not include a cigarette, and select an object that was most closely related to the item pictured—in this case, an ashtray. He further explained:

> Oddly enough, however, even after their correct response, and while they were holding the ashtray in their left hand, they were unable to name or describe the object or the picture of the cigarette. Evidently, the left hemisphere was completely divorced, in perception and knowledge, from the right. (p. 26)

Other tests were conducted to shed additional light on the language-processing abilities of the right hemisphere. One very famous, ingenious, and revealing use of the visual apparatus came when the word HEART was projected to the patients so that HE was sent to the right visual field and ART was sent to the left. Now, keeping in mind (your connected mind) the functions of the two hemispheres, what do you think the patients verbally reported seeing? If you said ART, you were correct. However, and here is the revealing part, when the participants were presented with two cards with the words HE and ART printed on them and asked to point with the left hand to the word they had seen, they all pointed to HE! This demonstrated that the right hemisphere is able to comprehend language although it does so in a different way from the left: in a nonverbal way.

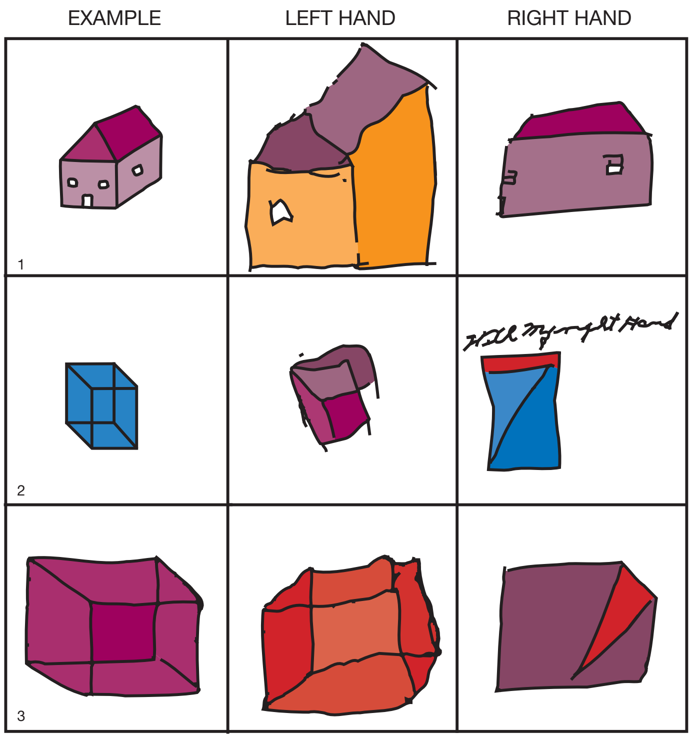
The auditory tests conducted with the patients produced similar results. When patients were asked to reach with their left hand into a grab bag hidden from view and pull out certain specific objects (a watch, a marble, a comb, a coin), they had no trouble. This demonstrated that the right hemisphere was comprehending language. It was even possible to describe a related aspect of an item with the same accurate results. An example given by Gazzaniga was when the patients were asked to find in a grab bag full of plastic fruit "the fruit monkeys like best," they retrieved a banana. Or when told "Sunkist sells a lot of them," they pulled out an orange. However, if these same pieces of fruit were placed out of view in the patients' left hand, they were unable to say what they were. In other words, when a verbal response was required, the right hemisphere was unable to speak.

One last example of this amazing difference between the two hemispheres involved plastic block letters on the table behind the screen. When patients were asked to spell various words by feel with the left hand, they had an easy time doing so. Even if three or four letters that spelled specific words were placed behind the screen, they were able, left-handed, to arrange them correctly into words. However, immediately after completing this task, the participants could not name the word they had just spelled. The left hemisphere of the brain is superior to the right for speech (in some left-handed people, this is reversed). But in what skills, if any, does the right hemisphere excel? Sperry and Gazzaniga found in this early work that visual tasks involving spatial relationships and shapes were performed with greater proficiency by the left hand (even though these patients were all right-handed). As seen in Figure 1.1.3, participants who copy three-dimensional drawings (using the pencil behind the screen) were much more successful when using their left hand.

The researchers wanted to explore emotional reactions of split-brain patients. While performing visual experiments, Sperry and Gazzaniga suddenly flashed a picture of a

Figure 1.1.3 Drawings made by split-brain patients.

SOURCE: Adapted from p. 27, "The Split Brain in Man," by Michael S. Gazzaniga.



nude woman to either the left or right hemisphere. In one instance when this picture was shown to the left hemisphere of a female patient:

> She laughed and verbally identified the picture of a nude. When it was later presented to the right hemisphere, she said . . . she saw nothing, but almost immediately a sly smile spread over her face and she began to chuckle. Asked what she was laughing at, she said: "I don't know . . . nothing . . . oh—that funny machine." Although the right hemisphere could not describe what it had seen, the sight nevertheless elicited an emotional response like the one evoked in the left hemisphere. (p. 29).

Discussion

The overall conclusion drawn from the research reported in this article was that two different brains exist within each person's cranium—each with complex abilities. Gazzaniga notes the possibility that if our brain is really two brains, then perhaps we have the potential to process twice as much information if the two halves are divided. Some research evidence suggests that split-brain patients have the ability to perform two cognitive tasks as fast as a normal person can carry out one.

Significance of Findings

These findings and subsequent research carried out by Sperry, Gazzaniga, and others were significant and far-reaching. They demonstrated that the two halves of your brain have many specialized skills and functions. Your left brain is "better" at speaking, writing, mathematical calculation, and reading, and it is the primary center for language. Your right hemisphere, however, possesses superior capabilities for recognizing faces, solving problems involving spatial relationships, symbolic reasoning, and artistic activities. In the years since Sperry and Gazzaniga's "split-brain" discoveries, psychobiological researchers have continued to uncover the amazing complexities of the human brain. Our brains are far more divided and compartmentalized than merely two hemispheres. We now know that a multitude of specific structures within the brain serve very specialized cognitive and behavioral functions.

Our increased knowledge of the specialized functioning of the brain allows us to treat victims of stroke or head injury more effectively. By knowing the location of the damage, we can predict what deficits are likely to exist as a patient recovers. Through this knowledge, therapists can employ appropriate relearning and rehabilitation strategies to help patients recover fully and quickly.

Gazzaniga and Sperry, after years of continuous work in this area, suggested that each hemisphere of your brain really is a mind of its own. In a later study, split-brain patients were tested on much more complex problems than have been discussed here. One question asked was "What profession would you choose?" A male patient verbally (left hemisphere) responded that he would choose to be a draftsman, but his left hand (right hemisphere) spelled, by touch in block letters, *automobile racer* (Gazzaniga & LeDoux, 1978). Gazzaniga has taken this theory a step further. He has proposed that even in people whose brains are normal and intact, the two hemispheres may not be in complete communication (Gazzaniga, 1985). For example, if certain bits of information, such as those forming an emotion, are not stored in a linguistic format, the left hemisphere may not have access to it. The result of this is that you may feel sad and not be able to say why. As this is an uncomfortable cognitive dilemma, the left hemisphere may try to *find* a verbal reason to explain the sadness (after all, language is its main job). However, because your left hemisphere does not have all the necessary data, its explanation may actually be wrong!

Criticisms

The findings from the split-brain studies carried out over the years by Sperry, Gazzaniga, and others have rarely been disputed. The main body of criticism about this research has focused instead on the way the idea of right- and left-brain specialization has filtered down to popular culture and the media.

A widely believed myth states that some people are more *right-brained* or more *left-brained*, or that one side of your brain needs to be developed in order for you to improve certain skills (more on this next). Jerre Levy, a psychobiologist at the University of Chicago, has been in the forefront of scientists trying to dispel the notion that we have two separately functioning brains. She claims that it is precisely because each hemisphere has separate functions that they must integrate their abilities instead of separating them as is commonly believed. Through such integration, your brain is able to perform in ways that are greater than and different from the abilities of either side alone.

When you read a story, for example, your right hemisphere is specializing in emotional content (humor, pathos), picturing visual descriptions, keeping track of the story structure as a whole, and appreciating artistic writing style (such as the use of metaphors). While all this is happening, your left hemisphere understands the written words, deriving meaning from the complex relationships among words and sentences, and translating words into their phonetic sounds so that they can be understood as language. The reason you are able to read, understand, and appreciate a story is that your brain functions as a single, integrated structure (Levy, 1985).

In fact, Levy explains that no human activity uses only one side of the brain: "The popular myths are interpretations and wishes, not the observations of scientists. Normal people have not half a brain, nor two brains, but one gloriously differentiated brain, with each hemisphere contributing its specialized abilities" (Levy, 1985, p. 44).

Recent Applications

The continuing influence of the split-brain research by Sperry and Gazzaniga echoes the quote from Levy. A review of recent medical and psychological literature reveals numerous articles in various fields referring to the early work and methodology of Roger Sperry, as well as to more recent findings by Gazzaniga and his associates. For example, a study from 1998 conducted in France (Hommet & Billard, 1998) has questioned the foundations of the Sperry and Gazzaniga studies—namely, that severing the corpus callosum actually divides the hemispheres of the brain. The French study found that children born without a corpus callosum (a rare brain malformation) demonstrated that information was being transmitted between their brain hemispheres. The researchers concluded that significant connections other than the corpus callosum must exist in these children. Whether such subcortical connections are present in split-brain individuals remains unclear.

Recent research has sounded an additional note of caution in how educators might be tempted to apply Gazzaniga's findings (Alferink & Farmer-Dougan, 2010). The widespread belief that different brain hemispheres control distinct cognitive functions has been clearly demonstrated only in a *selected* number of patients who, for specific medical reasons have undergone the surgical procedure of severing the corpus callosum, we should not assume that the findings from these individuals should apply to everyone whose brains are intact. To leap from the assumption that different brain hemispheres are responsible for unique tasks to formulating education models based on these findings is risky. The point some researchers make is that the patients on whom this research was based displayed non typical brain function even before the surgery. Therefore, to assume that educational methodology should focus on one hemisphere or the other for those with normal nonsevered brain functioning should be avoided.

Researchers continue to explore the idea that our two brain hemispheres have separate, yet distinct, functions and influences. One such study (Morton, 2003) demonstrated how your dominant hemisphere may lead you toward specific interests and professions. Morton's research made two discoveries in this regard. Using a special written test called "The Best Hand Test," which measures *hemisphericity* (whether a person is right- or left-brain oriented), Morton found that among 400 students enrolled in first-year, general college courses, 56% were left-brain oriented. However, when the same methods applied to 180 students in various, *specialized* upper-level courses, the range of left-brain students ranged from 38% to 65%. This difference indicated that something about a person's brain hemispheres was associated with spreading students out over a variety of college degrees and interests. Second, and more revealing, Morton employed the same method in determining the hemispheric orientation of members of various professions in university settings. The findings indicated that hemispheric specialization appears to be predictive of professional choices. For example, among biochemists, Morton found that 83% were left-brain oriented, while among astronomers only 29% showed a left-brain preference (p. 319). You can see how this would make sense in relation to Sperry and Gazzaniga's work. Biology and chemistry rely more heavily on linguistic abilities whereas astronomers must have greater abilities in spatial relationships (no pun intended).

Conclusion

Gazzaniga (now at the University of California at Santa Barbara) and his associates continued to study hemispheric specialization and continued to make new discoveries. Using new, sophisticated imaging and analysis techniques, a study in his lab found that healthy individuals (those with intact brains) appear to have more trouble processing language that is projected only to their right brain, *even though the two hemispheres are connected*. The researchers showed participants either a real word or a non word that looked like a word (not just gibberish) to left or right hemispheres and found that when shown to the right side the participants had more trouble distinguishing between the real and fake words. These findings shed light on the types of connections that function in transferring information between the two sides of your brain (Gallessich, 2012).

Other behavioral scientists have carried this separate-brain idea a step further and applied it to some psychological disorders, such as dissociative, multiple personality disorder (e.g., Schiffer, 1996). The idea behind this notion is that in some people with intact, "nonsplit" brains, the right hemisphere may be able to function at a greater-than-normal level of independence from the left, and it may even take control of a person's consciousness for periods of time. Is it possible that multiple personality disorder might be the expression of hidden personalities contained in our right hemispheres? It's something to think about . . . with *both* of your hemispheres.

Alferink, L., & Farmer-Dougan, V. (2010). Brain-(not) based education: Dangers of misunderstanding and misapplication of neuroscience research. *Exceptionality*, *18*, 42–52.

Gallessich, G. (2012). UCSB scientists report 'new beginning' in split-brain research, using new analytical tools. *The UC Santa Barbara Current*, *November 1*. Retrieved from www.news.ucsb.edu/2012/013395/ucsb-scientists-report-%E2%80%98new-beginning-split-brain-research-using-new-analytical-tools.

Gazzaniga, M. S. (1985). *The social brain.* New York: Basic Books.

Gazzaniga, M. S., & LeDoux, J. E. (1978). *The integrated mind.* New York: Plenum Press.

Hommet, C., & Billard, C. (1998). Corpus callosum syndrome in children. *Neurochirurgie*, *44*(1), 110–112.

Levy, J. (1985, May). Right brain, left brain: Fact and fiction. *Psychology Today,* 42–44.

Morton, B. E. (2003). Line bisection-based hemisphericity estimates of university students and professionals: Evidence of sorting during higher education and career selection. *Brain and Cognition*, *52*(3), 319–325.

Puente, A. E. (1995). Roger Wolcott Sperry (1913–1994). *American Psychologist*, *50*(11), 940–941.

Schiffer, F. (1996). Cognitive ability of the right-hemisphere: Possible contributions to psychological function. *Harvard Review of Psychiatry*, *4*(3), 126–138.
Sperry, R. W. (1968). Hemisphere deconnection and unity in conscious awareness. *American Psychologist*, *23*, 723–733.

Reading 1.2: More Experience = Bigger Brain

Rosenzweig, M. R., Bennett, E. L., & Diamond, M. C. (1972). Brain changes in response to experience. *Scientific American*, *226*(2), 22–29.

1.2 **Evaluate how Rosenzweig's research on the social environment of rats has influenced analysis and understanding of brain enrichment in humans**

If you were to enter the baby's room in a typical American home today, you would probably see a crib and baby's room full of stuffed animals and various colorful toys dangling directly over or within reach of the infant. Some of these toys may light up, move, play music, or do all three. What do you suppose is the parents' reasoning behind providing infants with so much to see and do? Aside from the fact that babies seem to enjoy and respond positively to these toys, most parents believe, whether they verbalize it or not, that children need a stimulating environment for optimal intellectual development and brain growth.

The question of whether certain experiences produce physical changes in the brain has been a topic of conjecture and research among philosophers and scientists for centuries. In 1785, Vincenzo Malacarne, an Italian anatomist, studied pairs of dogs from the same litter and pairs of birds from the same batches of eggs. For each pair, he would train one participant extensively over a long period of time while the other would be equally well cared for but untrained. He discovered later, in autopsies of the animals, that the brains of the trained animals appeared more complex, with a greater number of folds and fissures. However, this line of research was discontinued for unknown reasons. In the late 19th century, attempts were made to relate the circumference of the human head with the amount of learning a person had experienced. Although some early findings claimed such a relationship, later research determined that this was not a valid measure of brain development.

By the 1960s, new technologies had been developed that gave scientists the ability to measure brain changes with precision using high-magnification techniques and assessment of levels of various brain enzymes and neurotransmitter chemicals. Mark Rosenzweig and his colleagues Edward Bennett and Marian Diamond, at the University of California at Berkeley, incorporated those technologies in an ambitious series of 16 experiments over a period of 10 years to try to address the issue of the effect of experience on the brain. Their findings were reported in the article discussed in this chapter. For reasons that will become obvious, they did not use humans in their studies, but rather, as in many classic psychological experiments, their subjects were rats.

Theoretical Propositions

Because psychologists are ultimately interested in humans, not rats, the validity of using nonhuman subjects must be demonstrated. In these studies, the authors explained that for several reasons, using rodents rather than higher mammals such as primates was scientifically sound as well as more convenient. The part of the brain that is the main focus of this research is smooth in the rat, not folded and complex as it is in higher animals. Therefore, it can be examined and measured more easily. In addition, rats are small and inexpensive, which is an important consideration in the world of research laboratories (usually underfunded and lacking in space). Rats bear large litters, and this allows for members from the same litters to be assigned to different experimental conditions. The authors point out that various strains of inbred rats have been produced, and this allows researchers to include the effects of genetics in their studies if desired.

The main hypothesis implicit in Rosenzweig's research was the idea that animals raised in highly stimulating environments will demonstrate differences in brain growth and chemistry when compared with animals reared in plain or dull circumstances. In each of the experiments reported in this article, 12 sets of 3 male rats, each set from the same litter, were studied.

Method

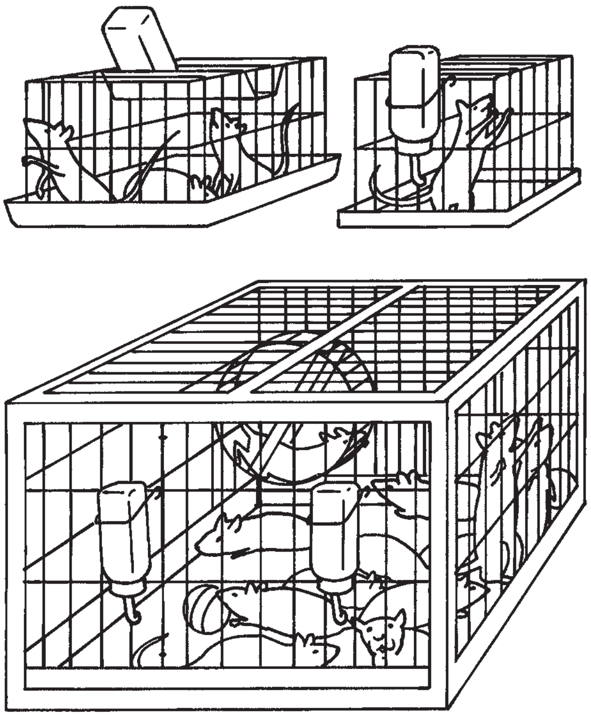
Three male rats were chosen from each litter. They were then randomly assigned to one of three conditions. One rat remained in the laboratory cage with the rest of the colony, another was assigned to what Rosenzweig termed the "enriched" environment cage, and the third was assigned to the "impoverished" cage. Remember, 12 rats were placed in each of these conditions for each of the 16 experiments (that's 576 rats).

The three different environments (Figure 1.2.1) were described as follows:

1. The standard laboratory colony cage contained several rats in an adequate space with food and water always available.
2. The impoverished environment was a slightly smaller cage isolated in a separate room in which the rat was placed alone with adequate food and water.
3. The enriched environment was virtually a rat's Disneyland (no offense intended to Mickey!). Six to eight rats lived in a large cage furnished with a variety of objects with which they could play. A new set of rat toys, from a selection 25 objects, was placed in the cage each day, so the enriched rats experienced a lot of variety or play activities.

The rats were allowed to live in these different environments for various periods of time, ranging from 4 to 10 weeks. Following this differential treatment period, the experimental rodents were examined to determine if any differences had developed in

Figure 1.2.1 Rosenzweig's three cage environments.



brain development. To be sure that no experimenter bias would occur, the examinations were done in random order by code number so that the person doing the autopsy would not know in which condition the rat was raised in order to avoid any unintentional bias.

The rats' brains were then measured, weighed, and analyzed to determine the amount of cell growth and levels of neurotransmitter activity. In this latter measurement, one brain enzyme was of particular interest: *acetylcholinesterase* (abbreviated AChE). This brain chemical is important because it allows for faster and more efficient transmission of impulses among brain cells.

Did Rosenzweig and his associates find differences in the brains of rats raised in enriched versus impoverished environments? The following are their results.

Results

Results indicated that the brains of the enriched rats were indeed different from those of the impoverished rats in many ways. The *cerebral cortex* (the part of the brain that responds to experience and is responsible for movement, memory, learning, and sensory input: vision, hearing, touch, taste, and smell) of the enriched rats was significantly heavier and thicker. Also, greater activity of the nervous system enzyme acetylcholinesterase, mentioned previously, was found in the brain tissue of the rats with the enriched experience.

Although no significant differences were found between the two groups of rats in the number of brain cells (*neurons*), the enriched environment produced larger neurons. Related to this was the finding that the ratio of RNA to DNA, the two most important brain chemicals for cell growth, was greater for the enriched rats. This implied that a higher level of chemical activity had taken place in the enriched rats' brains.

Rosenzweig and his colleagues stated that "although the brain differences induced by environment are not large, we are confident that they are genuine. When the experiments are replicated, the same pattern of differences is found repeatedly. . . . The most consistent effect of experience on the brain that we found was the ratio of the weight of the cortex to the weight of the rest of the brain: the sub-cortex. It appears that the cortex increases in weight quite readily in response to experience, whereas the rest of the brain changes little" (p. 25). This measurement of the ratio of the cortex to the rest of the brain was the most accurate measurement of brain changes because the overall weight of the brain may vary with the overall weight of each animal. By considering this ratio, such individual differences are canceled out. Figure 1.2.2 illustrates this finding for all 16 studies. As you can see, in only one experiment was the difference *not* statistically significant.

The researchers reported a finding relating to the two rat groups' brain *synapses* (the points at which neurons meet). Most brain activity occurs at the synapse, where a nerve impulse is either passed from one neuron to the next so that it continues on, or it is inhibited and stopped. Under great magnification using the electron microscope, the researchers found that the synapses of the enriched rats' brains were 50% larger than those of the impoverished rats, potentially allowing for increased brain activity.

Discussion and Criticisms

After nearly 10 years of research, Rosenzweig, Bennett, and Diamond were willing to state with confidence, "There can now be no doubt that many aspects of brain anatomy and brain chemistry are changed by experience" (p. 27). However, they were also quick to acknowledge that, when they first reported their findings, many other scientists were skeptical because such effects had not been so clearly demonstrated in past research. Some criticism contended that perhaps it was not the enriched environment that produced the brain changes but rather other differences in the treatment of the rats, such as mere handling or stress.