Left Brain Right Brain

Springer/Deutsch

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W. H. FREEMAN AND COMPANY
San Francisco

Project Editor: Judith Wilson
Copy Editor: Patricia Herbst
Designers: Marie Carluccio and Sharon H. Smith
Production Coordinator: Linda Jupiter
Illustration Coordinator: Audre Loverde
Artist: Sandra McMahon
Compositor: Graphic Typesetting Service
Printer and Binder: The Maple-Vail Book Manufacturing Group

Library of Congress Cataloging in Publication Data

Springer, Sally P 1947-
Left brain, right brain.

(A series of books in psychology)
Bibliography: p.
Includes index.
1. Cerebral dominance. 2. Brain—Localization of functions. 3. Left and right (Psychology) I. Deutsch, Georg, joint author. II. Title. [DNLM: 1. Brain—Physiology. 2. Laterality—Physiology. WL 335 S753L]
QP385.5.S67 612′.82 80–25453
ISBN 0–7167–1269–5
ISBN 0–7167–1270–9 (pbk.)

Printed in the United States of America

9 8 7 6 5 4 3 2

To the memory of
Fanny Margulies and Peter Deutsch

Preface

Assigning functions to specific regions of the brain is a recurring theme in the relatively brief history of human brain research. Nowhere has this been more evident than in the attempt to divide human mental functions along the most obvious physical division of the brain—its separation into a left half and right half. Asymmetries in hemispheric function were first discovered in the nineteenth century by observers noting the differing effects of injury to the left and right halves of the brain. In the ensuing years, clinical investigators continued to document consistencies in the behavioral consequences of such injuries.

Interest in this topic dramatically increased after the split-brain operations of the 1960s and led to an explosion of research seeking to characterize the differences and to explore their implications for human behavior. Considerable attention has also been directed to seeing whether these differences may be related to diverse phenomena such as learning disabilities, psychiatric illness, and variations in cognitive styles among cultures. The topic of functional asymmetry has been controversial for at least two reasons. First, findings have not always been consistent. Investigations designed to answer the same question have sometimes produced conflicting results. Second, the temptation to speculate and draw conclusions well beyond those justified by the data has been great.

This book is an attempt to bring together a great deal of research into the nature of hemispheric asymmetries. We first present basic findings on asymmetry in brain-damaged, split-brain, and normal subjects, and then we consider special topics such as left-handedness, sex differences in brain asymmetry, and the development of asymmetry. In providing an overview of the left brain and right brain, we have tried to separate what is reasonably established as fact from what is purely speculative, without sacrificing the intrigue of either. In addition, we have sought wherever possible to identify potential explanations for inconsistent findings. We have also tried to show how the investigation of hemispheric asymmetry has yielded important insights about brain function in general. Studying the left brain and right brain is, after all, but one approach to brain research. We hope that this book conveys the sense in which it is a fruitful one.

We have written with a relatively broad audience in mind. Our intention was to be as clear as possible without compromising accuracy or understating the complexity of the issues. The text will be useful in a wide range of graduate and undergraduate courses, both basic and applied, dealing with brain–behavior relationships. We feel that it will also interest general readers who would like to learn more about brain asymmetries and wish to go beyond oversimplified or exaggerated popular accounts.

We wish to thank several colleagues and friends for their contributions to the project. Bob Liebert got us started by asking for a reference reviewing the nature of hemispheric differences. When he was told that nothing appropriate was available, he suggested that perhaps it was time to write a book. Alan Rubens, Chuck Hamilton, Phil Bryden, Morris Moscovitch, and Barry Lorinstein each made valuable comments and suggestions on various aspects of the text. Our original, cumbersome title was shortened by Peter Schulman. We would also like to add a special note of thanks to our editor, W. Hayward Rogers, for enthusiastically sharing our belief that this book should be written.

November 1980

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A Historical Overview of Clinical Evidence for Brain Asymmetries

In 1836, Marc Dax, an obscure country doctor, read a short paper at a medical society meeting in Montpellier, France. Like most of his contemporaries, Dax was not a frequent contributor to medical conferences. In fact, this paper was to be his first and only scientific presentation.

During his long career as a general practitioner, Dax had seen many patients suffering from loss of speech, known technically as *aphasia,* following damage to the brain. This observation was not new. Cases of sudden, permanent disruption in the ability to speak coherently had been reported by the ancient Greeks. Dax, however, was struck by what appeared to be an association between the loss of speech and the side of the brain where the damage had occurred. In more than 40 patients with aphasia Dax noticed signs of damage to the left half, or hemisphere, of the brain. He was unable to find a single case that involved damage to the right hemisphere alone. In his paper to the medical society, he summarized these observations and presented his conclusions: each half of the brain controls different functions; speech is controlled by the left half.

The paper was an unqualified flop. It aroused virtually no interest among those who heard it and was soon forgotten. Dax died the following year, unaware that he had anticipated one of the most exciting and active areas of scientific inquiry of the second half of the twentieth century—the investigation of the differences between the left brain and the right brain.

. . .

Although most of us think of the brain as a single structure, it is actually divided into halves. These two parts, or hemispheres, are tightly packed together inside the skull and are linked by several distinct bundles of nerve fibers, which serve as channels of communication between them.

Each hemisphere appears to be approximately a mirror-image of the other, very much in keeping with the general left–right symmetry of the human body. In fact, the control of the body's basic movement and sensation is evenly divided between the two cerebral hemispheres. This is done in a crossed fashion: the left hemisphere controls the right side of the body (right hand, right leg, etc.), and the right hemisphere controls the left side. Figure 1.1 shows this arrangement.*

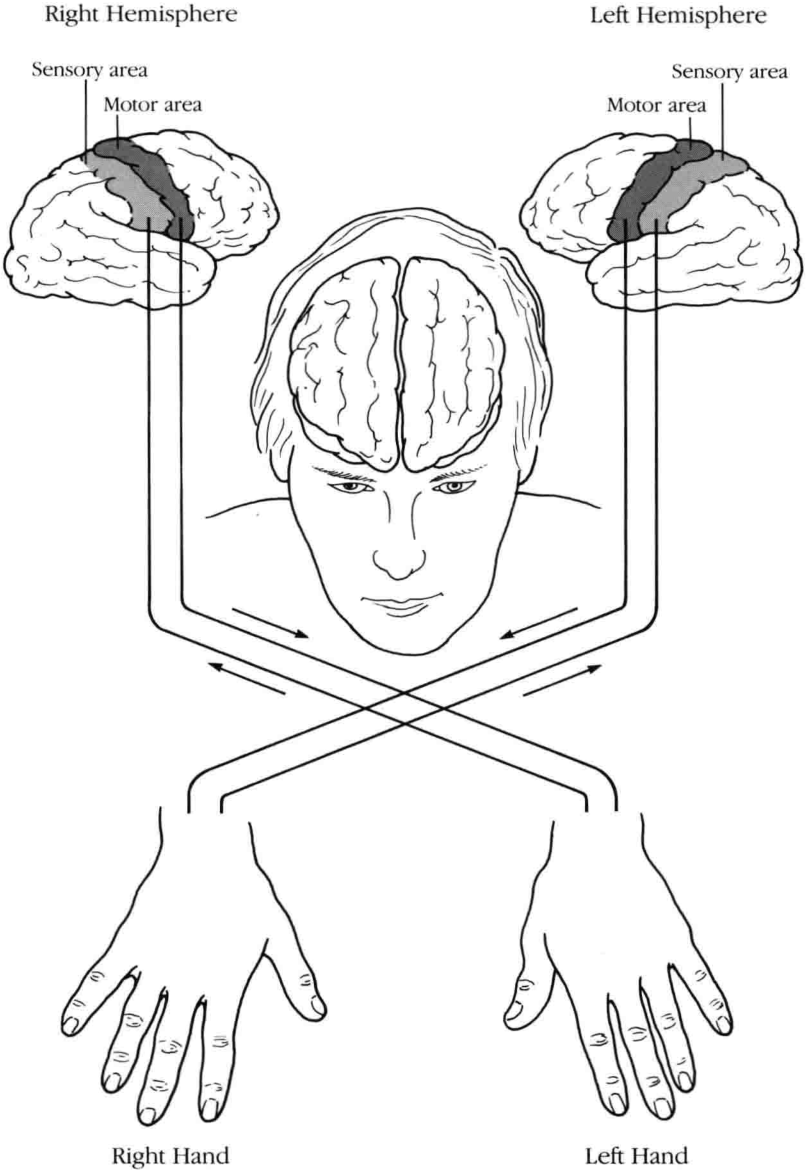
The left–right physical symmetry of the brain and body does not imply, though, that the right and left sides are equivalent in all respects. We have only to examine the abilities of our two hands to see the beginnings of *asymmetry of function*. Few people are truly ambidextrous; most have a dominant hand. In many instances a person's handedness can be used to predict a great deal about the organization of higher mental functions in her or his brain. In right-handers, for example, it is almost always the case that the hemisphere that controls the dominant hand is also the hemisphere controlling speech.

Differences in the abilities of the two hands are but one reflection of basic asymmetries in the functions of the two cerebral hemispheres. A great deal of evidence has accumulated in recent years showing that the left brain and right brain, though physically symmetrical, are not identical in their capabilities or organization. There is reason to believe that the most complex human mental functions and behaviors are asymmetrically divided between the left brain and right brain.

The earliest and most dramatic evidence of functional asymmetries comes from observations of the behavior of individuals with brain damage. Data of this type are known as clinical data because they are based on the study of patients with brain damage. Marc Dax's insight about the link between damage to the left hemisphere and loss of speech was the first recognition that the two hemispheres have different functions. Other asymmetries have been discovered as well.

For example, in contrast to people who experience speech problems because of damage to the left hemisphere, patients with certain kinds of right-hemisphere damage are much more likely to have per-

*A brief overview of neuroanatomy may be found in the Appendix.



1.1 Motor control and sensory pathways between the brain and the rest of the body are almost completely crossed. Each hand is primarily served by the cerebral hemisphere on the opposite side.

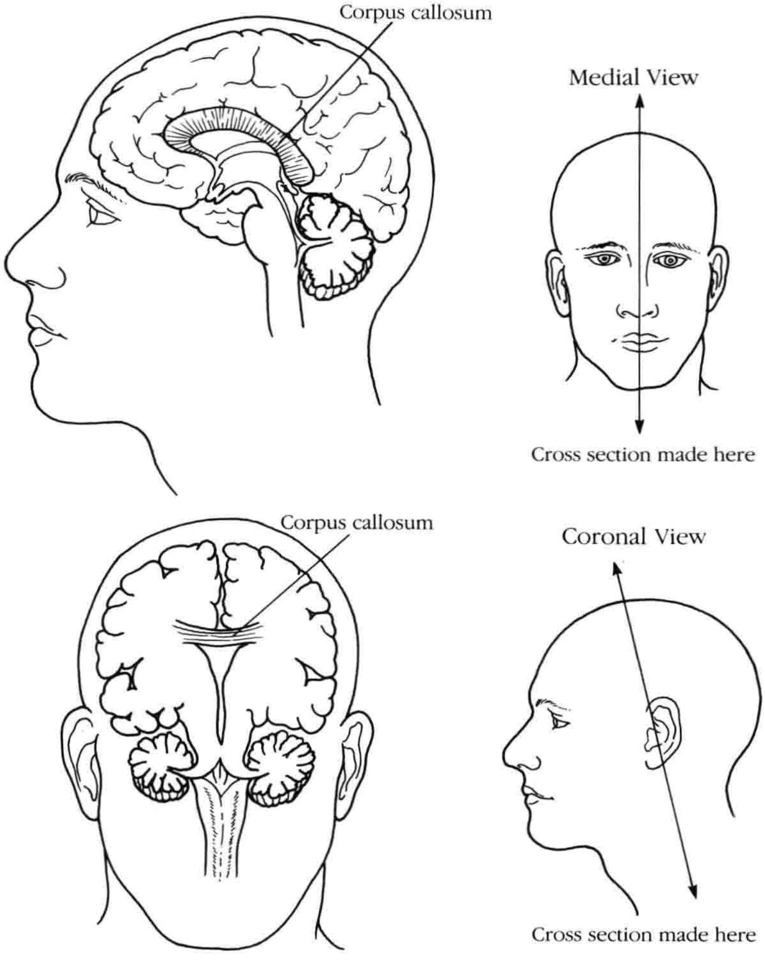
ceptual and attentional problems. These include serious difficulties in spatial orientation and memory for spatial relationships. For example, a patient may have great difficulty learning his or her way around a new building or may even be disoriented in familiar surroundings. Some right-hemisphere patients have difficulty recognizing familiar faces. Damage to the right hemisphere can also result in a problem called *neglect.* A patient experiencing the neglect syndrome pays no attention to the left side of space and sometimes pays no attention to the left side of his or her body. In many cases the patient will not eat food on the left side of the dinner plate and may refuse to acknowledge a paralyzed left arm as being his or her own. Surprisingly, similar damage to the left hemisphere usually does not produce such severe and long-lasting neglect of the right side of space.

Although clinical data pointing to brain asymmetries have been available for over 100 years, current interest in the left brain and right brain is traceable to recent work involving so-called split-brain patients. For medical reasons, these patients have undergone surgery to cut the cortical pathways that normally connect the cerebral hemispheres. Figure 1.2 shows the corpus callosum, the major pathway involved. To the untrained observer, this radical surgery seems to do little to interfere with the patient's normal functioning. To the inquisitive scientist, however, it affords an unparalleled opportunity to study the abilities of each hemisphere separately within the same head.

Special techniques make it possible to confine detailed sensory information to just one hemisphere. The limiting of stimuli to one hemisphere is often called *lateralization.* One way to accomplish lateralization is to let a blindfolded patient feel an object with one hand only. A split-brain patient who does this with the right hand (which is controlled principally by the left hemisphere) will have no difficulty naming the object. But if the procedure is repeated, this time using the left hand, the patient will be unable to name the object. Apparently, information about the object does not get through to the speech centers located in the left hemisphere. Nevertheless, the patient can easily use his or her left hand to retrieve the object from a number of other objects hidden from sight. A casual onlooker might conclude that the left hand knew and remembered what it held even though the patient did not.

Taking advantage of other techniques that confine visual and auditory information to one hemisphere at a time, researchers have demonstrated significant differences in the capabilities of the two hemispheres in split-brain patients. The left hemisphere has been found to be predominantly involved with analytic processes, especially the production and understanding of language, and it appears to process input in a sequential manner. The right hemisphere appears to be responsible for certain spatial skills and musical abilities and to process information simultaneously and holistically.

Encouraged by dramatic discoveries with brain-damaged patients, investigators have sought ways to study hemispheric differences in neurologically normal subjects. Ideally, one would like to know if the



1.2 Two views of the cerebral hemispheres and the corpus callosum, the major nerve-fiber tract connecting them. (After Lindsay and Norman, *Human Information Processing,* p. 442, Academic Press, Inc., 1977.)

differences between the left brain and right brain found in brain-damaged patients have any consequences for the function of the normal brain. Ingenious techniques developed to answer this question have shown that they do.

Taken altogether, this clinical research has generated a great deal of excitement. It is now clear that there are differences in function between the two sides of the brain and that the differences are found in normal subjects as well as in patients. One consequence of these discoveries has been a wealth of speculation about what the asymmetries mean for behavior.

Results of the split-brain studies show that each half of the brain is capable of perceiving, learning, remembering, and feeling independently of the other, but that some differences exist in the way in which each deals with incoming information. Roger Sperry, one of the California Institute of Technology researchers who pioneered much of this work, believes that an independent stream of consciousness resides in each hemisphere of the split-brain patient.[1] He has suggested that the surgical division of the brain divides the mind into two separate realms of consciousness. Such speculation naturally leads to the possibility of dual consciousness in the intact, normal brain under certain conditions.

Other investigators have emphasized the significance of the differences between the hemispheres. It has been claimed that these differences clearly show the traditional dualisms of intellect versus intuition, science versus art, and the logical versus the mysterious. Psychologist Robert Ornstein believes brain research shows that these distinctions are not simply a reflection of culture or philosophy.[2] What used to be a belief in an Eastern versus a Western form of consciousness, he argues, now has a physiological basis in the differences between the two hemispheres.

It has also been suggested that lawyers and artists use different halves of the brain in their work and that the differences between the halves show up in activities not related to their work.[3] Others have extended this idea further and have claimed that everyone may be classified as a right-hemisphere person or as a left-hemisphere person, depending on which hemisphere guides the bulk of an individual's behavior.[4]

Recent interest in brain asymmetries has sparked concern with the general issue of handedness. Studies have shown differences between left-handers and right-handers in the way the brain is organized. What are the consequences, if any, of these differences for intelligence and for creativity? What factors produce left-handedness in the first place? Genes? Experience? Minor brain damage? These and other questions related to handedness have been the subject of intensive study in the last decade.

Various other issues have been related to research in hemispheric asymmetry. Diverse problems such as learning disabilities, stuttering, and schizophrenia have been associated with speculation about the abnormalities in the division of labor between the two hemispheres. Joseph Bogen, a neurosurgeon involved in split-brain research, believes that research on hemispheric differences has important implications for education.[5] He argues that the current emphasis on the acquisition of verbal skills and the development of analytic thought processes neglects the development of important nonverbal abilities. It is, he claims, "starving" one half of the brain and ignoring its potential contribution to the whole person.

From its modest beginnings in 1836, research on the left brain and right brain has gone on to capture the imaginations of scientists and laypersons alike. Few areas of scientific inquiry have generated so much interest from so diverse an audience. This has had both good and bad effects. On the positive side, vast quantities of new data have been collected in a short period of time, and investigators are hard at work considering the implications of their findings for important questions about human behavior.

On the negative side, there is a tendency to interpret every behavioral dichotomy, such as rational versus intuitive and deductive versus imaginative, in terms of the left brain and right brain. This occupational hazard has been named "dichotomania" by some. In addition, the dividing line between fact and fantasy has often been blurred, making it difficult for nonspecialists to know what is speculation and what has been firmly established as fact.

It is undoubtedly the case, however, that important insights into brain function and its relationship to behavior have resulted from the study of the left brain and right brain and that many more important discoveries remain to be made. The goals of this book are to survey the current state of knowledge and to point out the gaps that still exist.

We begin with an account of some of the clinical data that have given rise to current ideas concerning the left brain and right brain.

Loss of Speech and Right-Sided Weakness: Long Overlooked Evidence of Asymmetry

Anyone who walks through a stroke ward in a hospital cannot help but notice the fairly even division of patients into those with paralyzed left sides and those with paralyzed right sides. A stroke generally involves a stoppage of the blood supply to part of the brain and results in damage to the affected region. Because blood is supplied to each hemisphere separately, strokes usually affect only one-half of the brain. Since each half controls the opposite side of the body, paralysis of the right side indicates a stroke in the left hemisphere and left-sided paralysis indicates a stroke in the right hemisphere.

Throughout the long history of aphasia, the clinical combination of speech disturbances with weakness or paralysis of the right half of the body has been reported again and again. This amounted to a link