Half a Brain is Enough is the moving and extraordinary story of Nico, a little boy who at the age of three was given a right hemispherectomy to control intractable epilepsy. Antonio Battro, a distinguished neuroscientist and educationalist, charts what he calls Nico's 'neuroeducation' with humor and compassion in an intriguing book which is part case history, part meditation on the nature of consciousness and the brain, and part manifesto. Throughout the book Battro combines the highest standards of scientific scholarship with a warmth and humanity that guide the reader through the intricacies of brain surgery, neuronal architecture and the application of the latest information technology in education, in a way that is accessible and engaging as well as making a significant contribution to the current scientific literature.

Half a Brain is Enough will be compulsory reading for anyone who is interested in the ways we think and learn.

Born in Argentina, ANTONIO M. BATTRO is a physician and a cognitive psychologist graduated from the Universities of Buenos Aires and Paris. He was a fellow of the International Center of Genetic Epistemology at the University of Geneva and an associate director at the Ecole Pratique des Hautes Etudes in Paris. He received the Guggenheim, Fulbright and Eisenhower fellowships and was a visiting scholar at the graduate school of education at Harvard University. He has been honored with the Argentine National Science award and was an invited lecturer at the Pontifical Academy of Sciences. He is the author of several books, among them *Piaget: dictionary of terms*. He is a member of the Argentine Academy of Education.

Cambridge Studies in Cognitive Perceptual Development

The aim of this series is to provide a scholarly forum for current theoretical and empirical issues in cognitive and perceptual development. As the twenty-first century begins, the field is no longer dominated by monolithic theories. Contemporary explanations build on the combined influences of biological, cultural, contextual and ecological factors in well-defined research domains. In the field of cognitive development, cultural and situational factors are widely recognised as influencing the emergence and forms of reasoning in children. In perceptual development, the field has moved beyond the opposition of 'innate' and 'acquired' to suggest a continuous role for perception in the acquisition of knowledge. These approaches and issues will all be reflected in the series which will also address such important research themes as the indissociable link between perception and action in the developing motor system, the relationship between perceptual and cognitive development to modern ideas on the development of the brain, the significance of developmental processes themselves, dynamic systems theory and contemporary work in the psychodynamic tradition, especially as it relates to the foundations of self-knowledge.

Published titles include

Jacqueline Nadel and George Butterworth (eds)
Imitation in Infancy

Margaret Harris and Giyoo Hatano (eds)
Learning to Read and Write: a cross-linguistic perspective

Michael Siegal and Candida C. Peterson (eds)
Children's Understanding of Biology and Health

Paul Light and Karen Littleton
Social Processes in Children's Learning

Half a Brain is Enough

The Story of Nico

ANTONIO M. BATTRO

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press
The Edinburgh Building, Cambridge CB2 2RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521783071

First published 2000
Reprinted 2001
This digitally printed first paperback version 2006

A catalogue record for this publication is available from the British Library

ISBN-13 978-0-521-78307-1 hardback
ISBN-10 0-521-78307-0 hardback

ISBN-13 978-0-521-03111-0 paperback
ISBN-10 0-521-03111-7 paperback

For Ellen Winner and Howard Gardner

Contents

The poem "The Two-Sided Man", by Rudyard Kipling, published in *Rudyard Kipling Verse*, by Hodder, London, 1927 is reproduced by kind permission of A. P. Watt Ltd. on behalf of the National Trust for places of Historical Interest or Historical Beauty.

Preface

This is a short book about a long personal story about the brain, the mind, and education. It began some forty years ago when I received my degree as a physician from the University of Buenos Aires. After training in electroencephalography and neuroanatomy I won a scholarship from the University of Paris to do experimental research in perception with Paul Fraisse. After my doctorate in psychology, while I was taking courses in mathematical logic and philosophy at the University of Fribourg, Jean Piaget invited me to Geneva. I spent two years with Piaget as a fellow of the International Center for Genetic Epistemology. At that time I met Seymour Papert who was doing research on artificial intelligence with Marvin Minsky. Twenty years later at MIT he started a revolution in education with the computer language called Logo. I was then rapidly introduced to the humanitarian use of computers with handicapped children and returned to work in Buenos Aires with the deaf. With my student, and now my partner, Percival J. Denham, we began to extend new information and communications technology to a wider population of physically and mentally disabled children. In a few years of intensive work and travel we shared our expertise in many South American countries, particularly in Argentina and Brazil, where we gradually established the practice not only of clinical computing for disabled persons, but of a more inclusive digital education for all.

Then one day a five-year-old boy came to our laboratory to be introduced to the new digital environment of computers and networks. This

book is about Nico, an exceptional child who, two years prior to our meeting, had undergone a right hemispherectomy because of severe and intractable epilepsy. There are about one hundred people in the world with this condition, but each one is unique. This particular boy became my friend and my pupil, started school successfully and is now enjoying the fast-growing new world of knowledge. I am privileged to work with him. He has changed my views on the brain, education, and mental development. I thank him daily for the unique opportunity he has given us to learn more about ourselves, most especially that there is no such thing as half reasoning with half a brain.

Finally, I must heartily thank Harvard University for inviting me to be a visiting scholar at the Graduate School of Education and my friend Howard Gardner who encouraged me to write this book. His comments and critiques and those of my friends and colleagues: Fernando Vidal, Kurt Fischer, Thierry Deonna, Marvin Minsky, Balázs Gulyás, Jacques Vonèche, and Ralf Kockro, have helped me to follow the two interwoven threads of the book: the case history of a hemispherectomized child and the neurocognitive roots of education. I also thank Patrick Temple for his assistance with the English version of this text. My thanks also to Sarah Caro, my editor at Cambridge University Press, and to Steve Caro, the most able corrector.

For reasons of privacy I cannot mention the names of the family, teachers' and friends who are involved in making Nico's life worth living, but the reader can imagine my enormous debt to them all. They have kindly supported my passionate research into the best possible education for a bright mind with half a brain.

Glossary

Agents Elementary mind processes which perform simple actions and can interact in complex patterns. Agents are easy to understand while their interaction could be more difficult to explain (Minsky, 1986).

Brain images Slices of the brain by X-ray computer tomography (CT), positron emission tomography (PET), magnetic resonance imaging (MRI) and functional magnetic resonance imaging (fMRI). Brain images with better temporal precision require event related potentials (ERP), electrocorticography (ECo), electroencephalography (EEG), and magnetoencephalography (MEG).

Catastrophe theory Mathematical theory that models some unstable dynamic system where a small local perturbation can produce large global changes. It has been used in biology and psychology to describe and predict sudden and qualitative changes in form and behavior (Thom, 1972).

Cognitive illusion A bias of some intuitive judgments that are unreasonable but compelling (Tversy & Kahneman, 1982).

Compensatory analysis The study of the brain processes supporting a specific reorganization of behaviour.

Connection prism Elementary set of nodes and links that relate persons, machines (computers) and environments. The *World Wide Web* is a very large collection of connection prisms.

Cortical shift The substitution of one area of the cortex by another during action or thinking. This happens, for instance, when the

computer is operated with vocal commands instead of the hands in order to make a drawing. A cortical shift from the hand to the language area induces a new skill in the latter.

Cyclopean vision A central visual process that extracts information which is hidden when the visual stimuli are viewed monocularly. For instance a pattern of random dots may convey no significant information to the retinas but it can be fused at a higher cortical level and show a figure against the random background (Julesz, 1971).

Digital shift The change from the analog to the digital, from the continuous to the discrete. It happens, for instance when we make a click with the mouse.

Fractals Fragmented and irregular objects implying *scaling*, i.e. their degree of irregularity and/or fragmentation is identical at all scales (Mandelbrot, 1982).

Epigenesis In biology the term is related to the development of the embryo in a sequence of gradual diversification and differentiation of tissues from the initially undifferentiated zygote; in developmental psychology it suggests a qualitative transformation in the organization of our actions and thoughts during growth and implies novelty and creativity.

EQ, encephalisation quotient The ratio between the actual brain size and the size expected for an animal of equivalent body size (Jerison, 1979).

Genetic epistemology The study of the formation of knowledge and of the cognitive relations between the subject and the objects. It is not to be confused with genetic psychology which seeks within the study of the child the solution of general problems (intelligence, perception, etc.) and is not identical with child psychology, which is the study of the child himself (Piaget, 1949, Battro, 1973).

Hemianopia A partial loss in the visual field. In the intact brain the visual information from the right retinas (left visual field) of both eyes travel through the optic nerve, optic tract and optic radiations to the primary visual cortex in the right hemisphere, and signals from the left retinas (right visual field) go to the left hemisphere. In the case of a right hemispherectomy there is a loss of the left visual field: a left (homonymous) hemianopia.

Hemiplegia Paralysis of one half of the body following an injury of the motor areas and pathways in the brain.

Hemispherectomy A surgical intervention that removes the cortex of one hemisphere of the brain. In the case of a functional hemispherectomy some of the nervous tissue remains in situ but is entirely disconnected from the rest of the brain.

IQ, intellectual quotient The ratio between the mental age, measured by psychometric tests, and the chronological age (multiplied by 100). The Wechsler Intelligence Scale for Children, or Wisc measures a verbal IQ and a performance IQ.

Intellectual prosthesis Computer devices and software that provide assistance to some impaired cognitive processes in speaking, drawing, writing, learning, and perceiving.

Intrinsic geometry An example is the "turtle geometry" of the computer language Logo where complex geometric objects can be produced using few and simple local commands like Forward, Back, Right, Left, Pitch, Roll and Veer without the need of external coordinates (Papert, 1980, Reggini, 1985).

Lesion analysis A methodology that correlates a specific region of a damaged brain with changes in a particular behavior (Damasio & Damasio, 1989).

Multiple intelligence theory, MI The human mind shows at least eight separate modules or faculties called intelligences: spatial, logical-mathematical, linguistic, naturalist, musical, bodily-kinesthetic, interpersonal, and intrapersonal (Gardner, 1983, 1999).

Mental organ Equivalent of a physical organ in the mental realm. For Noam Chomsky the mental organs are genetically determined, as is the case of language. His view is opposed to the constructivist theory of Jean Piaget concerning knowledge and language (Piatelli-Palmarini, 1994).

Neuroeducation The theory and practice of the neurocognitive sciences in the field of education.

Neurophilosophy A theory that views philosophical problems in the light of the new facts and models proposed by the neurocognitive sciences, in particular that the mental processes are brain processes (Churchland, 1989).

Preformation All the parts of an adult organism are contained in miniature in the germ cell. It is the opposite view of epigenesis and excludes innovation, also in the psychological sense.

Split brain The result of a section (or absence) of the fibers connecting one hemisphere to the other (corpus callosum and other commissures). In the split brain condition the individual may show a disconnection between the cognitive activities of the two hemispheres (Gazzaniga, 1970).

Skill A capacity to act in an organized way in a specific context (Fischer and Bidell, 1998).

Stage A state of stable equilibrium during mental development. The stages are necessary steps during the child's growth process and were described by Jean Piaget in four periods: sensory-motor, preoperational (symbolic, representational), concrete operational and formal operational (Piaget & Inhelder, 1963).

Termites A name given to the gifted and talented subjects studied by Lewis M. Terman (1925–59).

Virtual reality A digital three-dimensional dynamic representation of any environment or object that allows exploration, interaction, and search.

Virtual brain A digital three-dimensional representation of a real brain, useful to study and simulate brain surgery on the computer.