The Mind-Brain Relationship
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By Regina Pally

in collaboration with David Olds

Foreword by Mark Solms

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SERIES PREFACE

THE INTERNATIONAL JOURNAL OF PSYCHOANALYSIS KEY PAPERS SERIES

This series brings together the most important psychoanalytic papers in the Journal's eighty-year history, in a series of accessible monographs, of which this is the first. The idea behind the series is to approach the JIP's intellectual resource from a variety of perspectives in order to highlight important domains of psychoanalytic enquiry. It is hoped that these volumes will be of interest to psychoanalysts, students of the discipline and, in particular, to those who work and write from an interdisciplinary standpoint. The ways in which the papers in the monographs are grouped will vary: for example, a number of 'themed' monographs will take as their subject important psychoanalytic topics, while others will stress interdisciplinary links (between neuroscience, anthropology, philosophy etc. and psychoanalysis). Still others will contain review essays on, for example, film and psychoanalysis, art and psychoanalysis and the worldwide JIP Internet Discussion Group, which debates important papers before they appear in the printed journal (cf. www.ijpa.org). The aim of all the monographs is to provide the reader with a substantive contribution of the highest quality that reflects the principal concerns of contemporary psychoanalysts and those with whom they are in dialogue. We hope you will find the monographs rewarding and pleasurable to read.

Paul Williams,
This accessible review by Regina Pally of aspects of the neuroscience literature relevant to psychoanalysts performs an immensely valuable service. The explosion of knowledge in this area over the past few decades makes it almost impossible for the uninitiated psychoanalytic reader to find his or her bearings in it. And yet find their bearings they must, for there is little doubt that the scientific study and treatment of mental disorders (indeed our understanding of the human mind in general) in the twenty-first century will proceed from the fundamental insights that recent neuroscience has generated. Psychoanalysts who fail to assimilate the new knowledge will be increasingly marginalised both scientifically and professionally, and will be unable to participate in this important intellectual revolution.

The first chapter of this book describes how neural circuitry develops epigenetically, in a manner that directly reflects early environmental influences. These experience-dependent circuits might literally be described as the fabric of the ego. The second chapter reviews perceptual mechanisms, emphasising 'top-down' influences (i.e. the impact of memory, motivation, emotion and attentional factors on current perceptual processing). Pally's review of these mechanisms seems to provide a basis for new insights into a host of clinical phenomena (e.g. transference, projection, hallucination) that have played an important part in the development of psychoanalytic models of the mind. The third chapter discusses the structure and function of memory. Few topics are of more importance for psychoanalytic practice than an understanding of the varieties and vagaries of human memory. The contemporary models surveyed by
Pally demonstrate the ongoing fertility of Freud's conception of the
dynamic properties and 'constructed' quality of memory. The
fourth chapter concerns emotion. Pally correctly emphasises the
'embodied' basis of emotional processing, and draws attention to
the unconscious basis and deep evolutionary roots of our emotions,
conceptualised by Freud as 'reproductions of very early, perhaps
even pre-individual, experiences of vital importance' (1926, Inhibi-
tions, Symptoms and Anxiety, S.E. 20, p. 133). The fifth chapter deals
with the perennally fascinating topic of hemispheric asymmetry.
Pally provides an introductory overview of right/left differences
and describes some of the striking phenomena revealed by split-
brain studies. She also offers some speculations on the possible
implications for psychoanalysis of the bicameral organisation of the
forebrain. The sixth and final chapter addresses the fashionable
topic of consciousness, the 'final frontier' of neuroscience. This last
chapter provides a systematic and comprehensive overview of the
state of the art in the field. Here we see how deeply engaged con-
temporary neuroscience is—no less than psychoanalytic metapsy-
chology—with its philosophical underpinnings.

This book makes it possible for the non-specialist reader to
grasp—almost in a single sitting—the main thrust of contemporary
brain research on a range of topics of vital interest to psychoanalysis.
Readers are bound to want to learn more about one or another of
these topics, and in this way, they will be effortlessly inducted into
this exciting new era of exploration and discovery in mental science.

Mark Solms,
INTRODUCTION

This collection of articles appeared as a series in the *International Journal of Psychoanalysis*. My purpose in writing these is to provide psychoanalysts and psychotherapists with the basic, fundamental scientific concepts of neurobiology that are relevant to clinical work with patients. In each article, whenever possible, I try to point out the clinical implications of the scientific data.

I am a psychiatrist and my practice consists mainly of long-term psychotherapy and psychoanalysis. I began reading about neuroscience in 1995, simply for interest, unrelated to my clinical work. However, it soon became clear that neuroscience has a lot to offer clinical work and I have been studying, teaching and writing about it ever since.

These articles contain a lot of neuroanatomy, physiology and experimental data, and for those unfamiliar with science this may be somewhat daunting. To avoid being overwhelmed, I want to encourage the reader not to get lost in the facts. The usefulness of neuroscience rests not in specific facts but in the main principles they illustrate. As a guide to what the important principles are, I include here a list of a few examples of neuroscience concepts that address important questions psychotherapists and psychoanalysts face regularly in their work: (1) how the past influences the present; (2) why we need to feel our feelings; (3) why making the unconscious conscious is therapeutic; (4) why verbalising feelings is therapeutic; (5) why we need other people; (6) how the mind and body are integrated with one another; (7) why we tenaciously hold on to belief systems, and how belief systems influence our perceptions, thoughts and behaviours;
(8) how anything we do 'repeatedly' or experience 'repeatedly' can be incorporated at an unconscious level and contribute to habits, character and our relationships with others; (9) how non-verbal behaviour affects both patient and therapist in the treatment situation.

Since in many ways neuroscience validates our theories, it is tempting to focus primarily on this aspect of neuroscience. I think however our work will benefit more from an approach in which the ideas of neuroscience are viewed as having merit in their own right. What I mean is that the value of neuroscience goes beyond its ability to prove or disprove any particular psychoanalytic or psychotherapeutic theory. Neuroscience has much to teach us about the workings of the mind, and about why people think, feel and behave as they do. My approach then is to use neuroscience as an additional tool for understanding patients and helping patients to understand themselves. Perhaps someday in the future we might speak of a 'neuroscience interpretation'.

Acknowledgements: I did not accomplish this task alone. First I want to thank my colleagues Hans Miller, John Schumann, Daniel Siegel and Allan Schore for having nurtured my interest in neuroscience, encouraged my writing and taught me much of what I know. I want to express my gratitude to my editors, Arnold Cooper and David Tuckett, for providing me with the unique opportunity to write this series. I am grateful to David Olds, who collaborated with me on the last article in the series, on the topic of consciousness. And of course my thanks to my husband and children for their patience.

Regina Pally,
Los Angeles, 2000.
1: HOW BRAIN DEVELOPMENT IS SHAPED BY GENETIC AND ENVIRONMENTAL FACTORS

We have entered an era of extraordinary discovery about the human brain. Old notions of dichotomy between mind versus brain, nature versus nurture, have been supplanted by a rich web of synergistic relations between mind and brain, nature and nurture. Specifically, according to modern neuroscience, this means that all mental phenomena are assumed to be the result of biological activity of neuronal circuits in the brain. The development of these circuits relies in part on genetic programmes, but is also heavily dependent on the individual's experiences within the environment.

Recognition of the remarkable degree to which brain development is experience-dependent is a striking example of how neuroscience can be integrated with psychoanalysis. These ideas can be considered to lend support to analytic assumptions that early developmental experiences shape subsequent psychological functioning. The overall aim of this book is to integrate the two fields by providing a schematic overview of neuroscience topics that are relevant to the theory and practice of psychoanalysis. In this way the reader will not only know facts about brain functions, but be able to think conceptually about how these functions operate with one another and how they may inform us about our analytic work.

For some, this way of considering 'The Mind' may be rather foreign and difficult to accept. However, as Olds and Cooper in their recent editorial on the value of neuroscience for psychoanalysis recommend: 'We should at least understand what we are being offered, before deciding whether or not' it is profitable to us (1997, p. 221).
The idea that mental life is derived from biological events in neuronal circuits is the reigning doctrine of neuroscience, and therefore must be taken as a starting point for understanding the empirical research based on it. For those who criticise these attempts at integration as 'reductionistic', I want to clarify that the emphasis here is that mental phenomena are derived from biological activity. There is no intention to equate the mental with the biological.

I have selected topics that are most readily integrated with psychoanalysis. In this first chapter I address the experience-dependent nature of brain development. The three subsequent chapters cover perception, memory and emotion, and the two following chapters address aspects of bilaterality and consciousness. The concepts build on one another with each subsequent chapter. The data presented throughout is the result of a compilation of animal research and human research, including in vivo PET scans and MRIs and computer models of brain function. Before proceeding to how brain development is shaped by environmental as well as genetic influences, some preliminary comments are necessary regarding the unique cellular architecture and the evolutionary history of the human brain.

**CELLULAR ARCHITECTURE OF THE BRAIN**

The brain consists of approximately 10 billion neurons \(10^9\) *all activated at the same time* (Edelman, 1992; Edelman & Tononi, 2000). Each individual neuron, with its axon and branching dendrites, makes a synaptic connection with approximately 60,000 to 100,000
other neurons. The total number of synaptic connections is in the range of $10^{97}$. The number of possible combinations of synaptic connections is in the range of $10^{10^{10}}$. This is more than the number of positively charged particles in the known universe! The almost infinite number of potential neuronal configurations provides for the brain's vast information processing capacity.

**Evolution of the Human Brain**

The architecture and organisation of the brain is the product of its evolutionary history, which indicates that the human brain has evolved and expanded, while still retaining features of three basic 'evolutionary ancestors', reptiles, lower mammals and primates (MacLean, 1990). As a result of natural selection, 'newer' brain structures, which could 'perform' more adaptive functions, were added on to, and integrated with, more primitive structures. The most primitive part, the brainstem, is responsible for vital functions of physiological survival, such as the sleep/wake cycle, heart rate, respiration and body temperature. In addition to the brainstem, the human brain contains structures that are remnants of 'ancestral' brains. Derived from reptilian ancestors is the striatum, also called the basal ganglia. It is responsible for behavioural motor routines that are unique to the particular species, such as territorial displays. Humans have few of the innate behavioural routines found in reptiles and lower animals. However, in humans, once a particular behaviour is repeated many times, such as riding a bicycle or playing a Mozart concerto, the motor patterns are stored in
the basal ganglia and can be activated as automatic motor routines. Derived from lower mammals is the palaeomammalian brain, or limbic system. It is associated with emotion and memory, as well as with uniquely mammalian behaviours such as nursing, parental care, play and the infant distress cry.

The most highly evolved part of the brain is the cortex, or neomammalian brain. The part of the cortex that reaches the greatest degree of development in humans is called the prefrontal cortex. It is the 'executive centre' of the brain, responsible for planning for the future, directed attention to a task, delay of gratification, affect regulation and voluntary control of movement (Damasio, 1994; Fuster, 1996). The 'higher', more advanced prefrontal cortex modulates the emotion, behaviour and body physiology processed by the 'lower', more primitive subcortical regions.

There is a tendency to speak about the brain as if a particular function is localised in a particular brain region. However, the brain operates as a dynamic integrated whole (Edelman, 1989). Even a simple perception, such as seeing a cat, involves circuits that traverse the brainstem, limbic system and prefrontal cortex.

GENETIC INFLUENCES ON BRAIN DEVELOPMENT

One half of the entire genome is dedicated to producing the brain, an organ that constitutes only 2 per cent of our body weight. For the nine months of gestation and for a few months after birth, brain growth and development is largely directed by
the genetic code (Scheibel & Conrad, 1993). For example, the process by which cells migrate from the primitive neural tube tissue to their final destination in the foetal brain is under direct genetic influence. Another example is that after cells migrate, they develop temporary connections, which 'hold the place' for the more permanent connections that follow. Abnormalities of cell migration may contribute to the development of schizophrenia. One example, after birth, is the myelin sheath, which permits more rapid conduction of impulses along the axon (Kinney et al., 1988). Primary sensory areas myelinate in the first months of life. The prefrontal cortex, a region of higher cognitive skills, begins myelinating at about 3 months of age and continues into young adulthood!

**ENVIRONMENTAL INFLUENCES ON BRAIN DEVELOPMENT**

The brain is 'born' prematurely. Therefore much of its development occurs postnatally and for many years afterwards. Despite all the rich anatomical connections created under genetic control, the genome is not sufficient to encode all the details as to which connections ultimately become functionally active. To a startling degree, it is interactions with the environment that stimulate the more precise wiring of neural connections (Scheibel & Conrad, 1993). Illustrations of the experience-dependent nature of brain development exist at every level of brain functioning, from the rapid growth of the brain in early childhood to the subtler modifications that occur throughout the lifespan.
Neuroscientists believe that the functional unit of mental activity is not the single neuron but a circuit of interconnecting neurons all activated at the same time. Perception, memory, emotion, even thoughts and behaviours, are all the product of activated neural circuits. Interactions with the environment cause neurons to wire into circuits, which are sometimes called neural networks or neural assemblies, terms derived from computer models of brain activity. When the brain is exposed to a new event, external (a face, a word) or internal (emotion, physiological state), a unique pattern of neurons is activated. In order to preserve this configuration, connections must be forged between the neurons, creating a new circuit that acts as a symbol, a representation of something in the outside or 'inside' world. In other words, information from internal and external sources is represented in the brain by complex configurations of interconnected neurons (Edelman, 1989).

Recognition occurs when we encounter something that evokes a neural pattern similar to one already preserved, as demonstrated in primate brains and in computer-based neural network modelling (Edelman, 1992; Grossberg, 1999). If a pattern of neurons 'lights up' when you first see the Mona Lisa, the next time you see it, a similar pattern will light up, giving you the sense of recognition. (This process is often referred to as 'pattern matching'.) Because there is redundancy of brain circuits, it is even more accurate to say

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1 For a discussion of the way in which psychoanalysis has tried to integrate some of these ideas about pattern-matching and neural circuitry see Basch, 1988 and Hadley, 1992.
that a number of specific neural circuits underlie a particular brain function (Edelman, 1989). Redundancy is adaptive, because if one circuit becomes damaged, another can take its place. Not only is there more than one circuit per function, but individual neurons participate in many circuits, in the way that pixels in a television screen participate in a number of images.

The process by which most neuroscientists suppose connections between neurons are forged is called 'Hebb's rule', which states that if two neurons tend to be electrically active at the same time they will automatically form a connection (Hebb, 1949). If they are already weakly connected, the synapses between them will become strengthened. With regard to brain development it is a matter of 'use it or lose it'. We are born with an overabundance of neurons and dendrites (Diamond, 1988). In the neonatal period a pruning process begins. As a result of experience-dependent circuit development, the neural paths that are used remain, while those that are not used die off.

The role of re-entry circuits

All localised brain regions are richly connected to other brain regions by interconnecting neurons that form re-entry circuits (Edelman, 1989). These circuits, which also depend on experience-dependent 'Hebbian' strengthening, automatically feed information processed in localised brain regions back and forth to other localised regions. It is known that individual attributes of the environment are processed separately. There are relatively sepa-
rate brain regions to process environmental features such as colour, contour, motion, sound. Other regions for processing the memory of these stimuli and other regions are specialised for co-ordinated motor responses to these stimuli. Through re-entry the brain co-ordinates the information from these separate stimulus processing regions. For example, information processed in the visual cortex, automatically influences processing in the auditory cortex and vice versa. Thus what you see will influence what you hear and what you hear influence what you see. Edelman emphasises that re-entry is an important component of the brain's ability to accomplish complex cognitive tasks.

*Sensitive periods for sensory cortex development*

Although it has been most extensively studied within the visual system, it is considered a general principle that for normal perceptual capacity to emerge, the sensory cortex must receive very specific kinds of stimulation within a particular time frame, or 'sensitive period'. *In utero* development provides only an approximate sketch of the wiring of the topographically arranged visual cortex. The more precise wiring requires stimulation from postnatal sensory experiences.

Animal experiments were conducted to illuminate the clinical observation that childhood cataracts, if not treated promptly, can lead to permanent blindness. These effects are limited to a sensitive period in childhood. Cataracts that develop later in life, but are surgically corrected, do not lead to blindness.