Notes on

The Executive Brain: Frontal Lobes and the Civilized Mind
By Elkhonon Goldberg

As a child Elkhonon Goldberg wondered why the orchestra required that funny man on the podium waving his hands, since he did not contribute anything audible to the music. In a similar vein, I recall remarking to a co-worker about the smooth confidence demonstrated by the president of our company as he fielded questions during a quarterly presentation. “Of course,” he answered, “that’s what he does all day.”

The function of leadership is elusive and has evolved in its critical aspect late in human society. It was mere centuries ago that military commanders would lead, in large part, through their courage on the frontline. This would be unthinkable in today’s complex military endeavors. Goldberg mentions that early music and theatre had no conductor or director. A modern orchestral piece would be cacophonic and untenable without the direction of the conductor. In modern theatre the theatrical director selects the rhythm, timing, emphasis, movement and other factors according to a personal interpretation of the play that is difficult to define but essential to its success. Goldberg's book, *The Executive Brain*, explains how the frontal lobes play a similar role to that of the CEO, the director, or the conductor. Their contribution is not as visible but they are essential to the coordination of the more easily measured talents within the brain.

The role of the frontal lobes eluded scientific understanding well after many of the functions of the other parts of the brain had been mapped. In his introduction to this book Oliver Sacks mentions that they were referred to as the silent lobes during his own medical student days. During the ’40s and ’50s a large minority of doctors worldwide felt they could sever the connection of the prefrontal cortex to the rest of the brain in order to treat psychosis, intractable pain, or antisocial behavior without serious impact to the rest of the individual. To this day, frontal lobe damage is difficult for a clinician to diagnose. A patient suffering damage to the frontal lobes may pass many standard tests for neurological wellness, even though family and friends will know that the sufferer “isn't the same person” they knew before.

The difficulty has been that any test that assesses the talents of the brain in isolation, such as IQ, vocabulary, or memory tests, will bypass the frontal lobes. The frontal lobes govern the coordination and synthesis of these talents in order to fulfill a goal or to carry out a plan. They are deeply involved with the questions of: why you want to do something; are you accomplishing what you want to do; and do you still want to do it. These abilities are known as the executive functions. Using clinical tales and research findings from his decades of experience, research, and clinical practice, Goldberg defines the executive functions of the frontal lobes, how they can be measured and understood scientifically, and the devastation to the individual that occurs when they are lost through accident or disease. He shows how these functions of leadership within the mind have their parallels in the leadership of people and organizations.

The scope of the book is large and covers many themes as they relate to the frontal lobes. Recent understanding of the frontal lobes has brought important insights into diseases such as Parkinsonism, Tourette's syndrome, Obsessive-Compulsive disorder, ADHD, and Schizophrenia. They are, in some respects, diseases of the frontal lobes. Goldberg devotes a chapter to his view of hemispheric specialization, providing evidence that the right hemisphere is essential to learning new skills or dealing with novel situations.

The Interconnectedness of the Frontal Lobes

Goldberg devotes a chapter to a concise overview of the brain's structures and neuro-chemical pathways. The term "frontal lobes" is used in this book to refer to a part of the frontal lobes called the prefrontal cortex. The neocortex, comprising the occipital, parietal, temporal, and frontal lobes, is the newest structure of the brain in evolutionary terms. In contrast, the brainstem and thalamus, which evolved millions of years before the cortex, are referred to as the reptilian brain. However, there are systems within the brainstem and in the cingulate cortex that work closely with the frontal lobes: Goldberg likes to think of them as the greater metropolitan frontal cortex. He emphasizes these because brain injury that impacts the connection between these systems and the frontal lobes can result in frontal lobes disease even without any apparent damage to the cortex itself.

There are two significant anatomical clues to the importance of the frontal lobes in humans. One is its sheer size in humans. The prefrontal cortex accounts for 29% of the human brain. It accounts for 17% in the chimpanzee, 8.5% in the lemur, 7% in the dog, and 3.5% in the cat. The other is how connected it is with the rest of the brain. Consistent with its job as command post, the prefrontal cortex is directly interconnected with every distinct functional unit of the brain. It is connected via nerve pathways to structures governing memory, movement, and emotion. It connects to the limbic system governing basic survival and homeostasis. It is connected with brainstem nuclei in charge of activation and arousal. The prefrontal cortex seems to contain a map of the different functional areas of the cortex.

Canary in a Mineshaft

The frontal lobes' interconnectedness with the rest of the brain enables it to do its remarkable job of activating, governing, and coordinating. However, this comes at the price of increased vulnerability. Damage to any other part of the brain seems to affect the frontal lobe, with diffuse brain damage being the most devastating. Goldberg offers the analogy of military command: A squadron of soldiers can perform its functions even though communication from command has been cut off. (Although they may not know when to start activities or when to terminate!) A general, however, is effectively crippled without adequate feedback from distant operations under his command.

The regional cerebral blood flow patterns are an indicator of functioning in the brain. When a location within the brain is damaged, the cerebral blood flow in that area is disrupted. What is surprising is that no matter where damage occurs in the brain, the cerebral blood flow in the frontal lobes is also disrupted. The significance of this finding is that a disease process that affects the brain generally, such as Alzheimer's, may impact frontal lobe functioning before it impacts other abilities such as memory or language. A theme that Goldberg develops throughout the book is that if sensitive measures of executive function can be developed then progressive brain diseases may be caught much earlier than they can with traditional cognitive tests.

Working Memory

The frontal lobes play a key role in the functioning of memory and yet this role has been debated for decades since it was first suggested by Alexandr Luria. Goldberg blames this on confusion between how memory is tested in a psychological experiment or a doctor's office and how it is actually used.

Memory is essential in day-to-day activities: where do you keep the butter; what street is the hardware store on; who looks after purchasing and procurement; what is your child's teacher's name. Each piece of information is part of a vast store of information in our brain. For any task, the information must be retrieved in the right order and it must be appropriate for that task. It also has to be discarded when you move on to a different task. The process of retrieving and retaining task-relevant information is known as *working memory*. It is governed by the frontal lobes; however, traditional memory research does not capture this relationship. When an experimenter or doctor tells someone to remember a series of words and repeat them back, the decision-making process shifts from the individual to the experimenter. There is no need for the frontal lobes in this situation and so their functionality remains hidden.

The frontal lobes do not store our memories but they know where in the brain to find them. They activate the memory while it is needed for a specific step in a task and then release it for the next step. Goldberg compares this capability to that of a CEO who may not have the technical skills to implement a new product line but knows who in the organization does. When the executive of a large company initiates a new direction, certain projects and individuals become "highly visible" because of their relevance to the initiative. This visibility, happily, changes and shifts over time.

At each stage in solving a problem, the frontal lobes may have to bring different types of memories on-line. The brain must manage the switch to different types of tasks throughout the day. When some of these tasks are going on in parallel, the challenge is greater. Working memory frequently suffers early on in the process of dementia. Goldberg reports that "Patients at early stages of dementia often report 'inane' actions. They may take dirty dishes to the bedroom instead of the kitchen, or open the refrigerator

looking for gloves." Problems with working memory may occur well before the patient has difficulty passing a diagnostic memory test.

Freedom of Choice, Ambiguity, and the Frontal Lobes

Goldberg asks us to consider the following everyday problems: (1) My checking account had the balance of $1000 and I withdrew $300. How much do I have left? (2) What shall I put on today: a blue jacket, a black jacket, or a gray jacket? (3) What is my dentist's telephone number? (4) Shall I go on vacation to the Caribbean, Hawaii, or Greece? (5) What is my boss's secretary's name? (6) Shall I order lobster fra diavolo, lamb chops, or chicken Kiev for dinner?

Questions 1, 3, and 5 require *veridical decision-making*. For each there is a single correct answer, all others being false. The other questions involve *adaptive decision-making*. There is no intrinsically correct answer that you could look up in an encyclopedia or solve mathematically. These situations require an understanding of internal and external contexts. In the above examples it is very much personal preference: you require access to your internal desires, likes and dislikes. Goldberg refers to this as *actor-centered* problem solving. With the question of clothes, a number of external factors, including fashion, social occasion, and weather play a role in deciding what to wear. (Although in Winnepeg at 40 below the decision-making becomes veridical again.)

The facility for adaptive decision-making lies at the heart of frontal lobe functioning. It governs the interplay of the outside environment—the social context we live in, the industry and competitive environment of a company, or the audience and cultural context of a play—with the inner personality, vision, and goals of the individual or leader.

The distinctions between adaptive and veridical decision-making are easily enough described and understood, but attempting to measure them scientifically is more challenging. How do you measure someone's ability to make adaptive, actor-centered decisions when there is no single correct answer on which to score them? Goldberg and his graduate student Ken Podell developed a procedure called the Cognitive Bias Task (CBT) to capture some of the nature of adaptive decision-making. In this task a subject is

shown a geometric (target) design, followed by two other designs. The subject is asked to "look at the target and select the choice you like the most." The subjects repeat this task over a large number of trials with different geometric shapes, choosing the one they like the best. The task is very ambiguous: which one do I like? Moreover, why should I "like" one geometric shape more than another? There is, in fact, a pattern to these geometric shapes: one of the choices always looks similar to the target shape.

They ran this experiment with healthy males and females and with patients with various types of brain damage. Damage to the frontal lobes dramatically changed the responses, whereas damage to other parts of the brain did not. Although there are no right answers to this task, healthy people tend to take one of two strategic approaches: one is to choose the most similar shape to the target. Goldberg and his student called this decision-making strategy *context-dependent*. The other approach is to choose a shape based on some stable preference such as color or shape. They called this strategy *context-independent*. Interestingly, males tend to choose the context-dependent approach, whereas females tend to choose the context-independent approach.

These strategies enable people to interpret ambiguous situations and to make decisions where there is no clear right or wrong answer. The frontal lobes are critical to this ability. When they removed the ambiguity to the test, simply by asking the subjects to choose the design that is most similar (or most different) from the target, the patients with frontal lobe damage could perform the task as well as the healthy individuals.

Adaptive decision-making ability appears to decline early in Alzheimer's disease. Goldberg and his colleagues ran the CBT test on patients at different stages of Alzheimer's. He found that even patients in the mild stages of Alzheimer's decline performed the actor-centered (ambiguous) form of the CBT much worse than the healthy control subjects did, whereas the ability to perform the veridical form of the test declined slowly with very little difference in the early stages. He notes that indecision, hesitation, and an increasing dependence on others for making choices is as common an early symptom of cognitive decline in the elderly as the better-known memory and word-finding difficulty.

The S Factor and the Theory of Mind

Goldberg tackles what it means to be smart or shrewd vs. being obtuse or "dumb." This quality is not measured by an IQ test, nor is it a composite of talents in music, math, art, or literature. Many forms of genius, he feels, reflect localized properties of the mind. He gives the example of Mozart and Alan Turing, who were geniuses respectively in music and math and yet in their day-to-day lives would not be considered smart by most people.

This brings us to one of the central aspects of being "smart." Most people will confidently rank others, given enough exposure, as being either comparatively smart or comparatively dumb as individuals. Goldberg envisions an experiment, in which a panel of judges, made up of ordinary people, is assembled to rank another group of subjects, again ordinary people, on how smart they are. This ranking would be based on a sample of live, one-on-one, freewheeling one-hour sessions of the subjects interacting with someone else or among themselves. Goldberg predicts that the judges' assessments would be very consistent with one another. He predicts further that if a battery of neuropsychological tests were administered to the subjects, the judges' assessments would be best correlated with the tests of executive functions. It is the executive intelligence that we intuitively recognize as "being smart." He refers to this—somewhat jokingly, perhaps—as the S factor, in comparison to the "G factor" (for general intelligence) that Psychologists have been attempting to define and measure for years.

Of the executive functions, however, it is the ability to understand the motivations and needs of others as separate from one's own that is at the heart of the S factor. For a military or corporate leader you must add to the functions of decision-making, planning, sequencing of steps, and assessment the ability to do this in coordination with the plans and actions of other institutions.

The ability to form a model in one's own mind of what other people are thinking, feeling, or needing is better known in neuropsychology as the "theory of mind." Goldberg gives a comic example of a patient who had a severe problem with forming a theory of mind. A man had been referred to him for neuropsychological evaluation. He was suffering from an unknown neurodegenerative disease. This patient appeared otherwise healthy and

answered the basic history-taking questions adequately and to the point. But when Dr. Goldberg asked him what his favorite pastimes were, the man answered "Movies!" with great excitement, at which point he launched into detailed descriptions of the movies he had seen recently, dozens of them. After 40 minutes of plot after plot, Goldberg finally interrupted him to move things along. Clearly, this patient had no concept of what his doctor needed to know. He also was unable to shut off his verbal output once it got started. Both of these are symptoms of frontal lobe damage, which later tests confirmed in this patient.

Drive and Initiative

Drive and initiative may not be executive functions, but they are certainly associated with success and achievement in our culture. The frontal lobes play an important role in governing drive. A condition called dorsolateral frontal lobe syndrome directly impacts one's ability to initiate behavior. Goldberg compares patients with this disease to bodies in Newtonian physics: To set a body (object) in motion, an external force must be applied. A body, once put in motion, can only be halted by applying an opposing force.

While Goldberg was a neuropsychology student in Moscow, his mentor Alexandr Luria sent him to study a patient at the Bourdenko Institute of Neurosurgery. Vladimir was an engineering student a couple of years older than Elkhonon. When the soccer ball he had been tossing around fell on the train rails, he jumped down to get it and was hit by an approaching train. The damage to his frontal lobes was severe enough that both had to be amputated. When Goldberg saw him for the first time a couple of months later, Vladimir spent most of his time in bed, staring blankly into space. He ignored most attempts to engage him. If a visitor or nurse were persistent enough, he would respond with profanities and possibly a hurled chamber pot.

With a great deal of coaxing and doubtless being fast on his feet, Goldberg was able to attempt various bedside experiments. Vladimir would follow his direction in a detached, zombielike fashion. Vladimir would never initiate any action or conversation by himself, but once started, he could not stop. When he was asked to draw a simple shape, he would continue drawing the same shape over and over. When asked to repeat a short tale, he

would drone on non-stop. The structure of the tale would be lost in endless circumstantial detail.

Vladimir had an extreme case of the dorsolateral frontal lobe syndrome. Where the dorsolateral damage is milder due to mild head trauma or the beginning stages of dementia, the change to the personality is less obvious. Goldberg relates the case of a woman in her fifties who was referred to him for a second opinion. A few years earlier she had been diagnosed with Parkinson's disease because she had developed tremors. She had been put on medication for this disease. But over time her family started noticing other cognitive impairment of attention, memory, and judgement. The doctors, assuming that this was a symptom of her Parkinson's, changed the dosage but her cognitive faculties deteriorated further, culminating in a psychotic episode.

She was brought to Goldberg for a second opinion. When he interviewed her, he felt that she exhibited the telltale signs of Lewy Bodies disease, a lesser-known cause of dementia. When he questioned her husband about the earlier stages of her symptoms, a very different picture emerged. At least a year prior to the tremors, this woman had begun to withdraw. She had always been a vivacious and sociable person who put a great deal of energy into entertaining. Then she began to refuse to go out, preferring to stay at home. She stopped entertaining, claiming that she had no energy or interest for it.

Social Maturity

A key motive for Goldberg in writing this book is to address the public blindspot towards the loss of higher-order functioning. This blindspot has had a long history. Antonio Damasio coined the phrase "Descartes' error" to refer to the dichotomy that Western society placed between body and mind. In the 17th century René Descartes argued that it is our brain and nervous system that enables us to move, to perceive the world through our senses, to remember, to sleep, and to dream. Yet he held that the soul must coexist with the brain and in some way operate the brain and nervous system.

Today this dichotomy shows itself in many guises. We talk about "the brain" and "the mind" as though they were separate entities, one physical the other spiritual. It plays out

in the difference between how physical illness is treated versus mental illness. Our capacity for social maturity and our ability to understand morality, to act on that understanding, and to understand the consequences of our actions, are assumed to be the functioning of the mind and not the brain. However, there are specific areas of the brain that, when damaged, affect these capabilities. When the orbitalfrontal part of the frontal lobes is damaged, it gives rise to a condition that used to be called "Pseudopsychopathic syndrome." Patients with this syndrome are impulsive and unable to control their emotions. They often engage in petty crime. Their behavior is like that of a delinquent teenager. Their humor, in fact, has been compared to a drunken teenager: profane and sexually explicit.

The term "pseudopsychopathic" is no longer used. Patients with orbitofrontal syndrome, as it is now called, are often relatively harmless. Goldberg relates the case of an elderly, wealthy country gentleman who was brought to him by the man's wife after he had bought 100 horses on an impulse. He was diagnosed with advanced dementia. When Goldberg asked his wife why she had not brought him to the doctor sooner, she replied that he had been acting silly for the last few years but she thought he had simply been "sloshed" on martinis.

So What Can You Do For Me?

Much of the material in the book covers what the executive functions are and the devastation caused by their loss. Goldberg spends a chapter considering the latest findings in prevention and cure. After covering the various classes of cognotropic drugs, he moves on to the efforts towards exercising the brain for recovery and prevention.

Cognitive rehabilitation had unpromising beginnings. Goldberg describes his mentor Luria's efforts to retrain soldiers suffering from head injury to use different functional systems to compensate for specific losses in capability. This met with little success. If a patient lost his memory due to head injury, he would be taught strategies to memorize longer and longer lists of words. The patient might learn to do this task effectively, but the capacity did not generalize to any other form or use of memory. In the decades since

then, when people suffered partial brain damage affecting language, memory, or reasoning, they would be given specific cognitive exercises targeting those functions.

Cognitive exercise has changed radically in the last decade or two, beginning with evidence that cognitive exercise changes the brain itself. Providing an environment rich in diverse sensory stimulation enabled animals with brain damage to regrow connection between the nerve cells far more rapidly than if they were in an ordinary environment. These animals also showed improved blood supply to the brain through the enhanced growth of small blood vessels. In this approach specific injury is improved by promoting the general health of the brain. Instead of targeted exercises, patients are given broad-based mental exercises to improve overall mental functioning. The analogy is of a tennis pro increasing her strength, coordination, and stamina in a very general way, rather than focussing only on improving her swing.

Brain plasticity refers to the brain's ability to recover from damage by using other parts of the brain to take on the function that was lost. This was observed primarily in the young. For the longest time it was thought that we lose this capacity as we get older. There is now evidence that we retain much of this ability throughout the life span. Mental decline was also considered inevitable with age. However, not everyone ages equally. There is increasing evidence that a mentally active lifestyle may protect the brain against Alzheimer's and other dementias. The most dramatic example of this came from a study of the School Sisters of Notre Dame, a convent from Mankato, Minnesota. The nuns from this convent were well known for their longevity and absence of Alzheimer's. The nuns constantly challenged their minds with puzzles, card games, debates of current policy issues, and other mental activities. In particular, Sister Mary performed well on cognitive tests until her death at the age of 101. A post-mortem autopsy revealed multiple neurofibrillary tangles and plaques, the hallmarks of Alzheimer's disease. Sister Mary had an intact mind inside an Alzheimer's brain.

A Fitness Program

Early symptoms of Alzheimer's, Lewy Bodies and other dementias vary a great deal. In many cases it starts with memory decline, but it may also start with language problems,

or spatial disorientation, or, as suggested in this book, impairment of insight, judgement, and initiative. It has been suggested that the part of the brain you use the most is also the best protected against these diseases. According to this view, an architect may protect the functioning of his parietal lobe (related to spatial reasoning), whereas a writer may protect her temporal lobe. An intriguing study of London taxi drivers lends credence to this hypothesis. British neuroscientists scanned the brains of 16 London taxi drivers and compared them to 50 control subjects. A structure of the brain known as the posterior hippocampi, or P.H., is believed to be involved in spatial learning and memory. The London taxi drivers must develop an intricate mental map of this huge city, which presumably would involve the P.H. The taxi drivers had larger posterior hippocampi compared to the control subjects. Amongst themselves the more years of experience they had, the larger the Hippocampi. This finding would have been considered impossible a few years ago.

This points to the possibility of a balanced mental fitness program, one that includes many areas of cognitive function. Goldberg compares this to the modern day fitness centers with equipment designed to ensure that all muscle groups are exercised. The cognitive equivalent would include mental "workouts" of diverse abilities, including executive functions such as decision-making, planning, coordinating, and assessment.

The Evolution of Leadership

The neocortex is the newest structure in the evolution of the brain and the prefrontal cortex is the newest structure of the cortex. The older structures of the brain, such as the brainstem and the thalamus, are highly modular. The functions within the brainstem and thalamus are governed by groups of nerve cells called nuclei. These nuclei communicate with one another through specialized and unchanging nerve pathways. Each of these nuclei carries a specific function or group of functions. By comparison, the organization of the neocortex is much freer and more complex. The modularity of the cortex is less defined than the sub-cortical structures. Goldberg describes a gradiential organization in which there is a gradual transition from one cognitive function to another as you travel across the surface of the cortex.

Compared to the discrete and specific functions of the thalamic structures, the cortex is highly flexible and interconnected. The frontal lobes provide a measure of control to what would otherwise be chaotic. The cortical functions in the other lobes are highly autonomous and capable of performing to a degree without the frontal lobes, as indicated by the superficial normality that a person with frontal lobe damage may exhibit. Rather than micromanaging every function, the frontal lobes provide a global measure of initiation, coordination and constraint to the vast number of neural structures within the brain.

In his concluding chapter Goldberg compares the evolution of the newer organization of the brain with the current momentous changes in global society. The strongly integrated nation-states are compared to the modular organization of the lower brain centers, whereas the newer organization suggested by the European Union is compared to that of the regions of the neocortex: highly interconnected and interdependent and yet also highly autonomous. However, I was more intrigued by his reference at the beginning of his book comparing leadership in ancient times with today. There have been leaders as far back as ancient history. One suspects that they were always high in the S factor. But the size and complexity of our modern society and institutions may demand much more of the executive functions of the frontal lobes than was required in ancient times.