



Book Review

The Executive Brain: Frontal Lobes and the Civilized Mind by Elkhonon Goldberg.
New York, Oxford University Press, 2001, paperback, 2002

Reviewed by Neil Greenberg

Elkhonon Goldberg provides a valuable and often fascinating overview of the functions of the human brain's frontal lobes from the clinician's vantage point. This (accurately) self-described "hybrid . . . idiosyncratic" book also incorporates a uniquely personal view on the workings of science. His reflections include his poignant rejection of his mentor's guarantee of professional success by joining the Communist Party and cafeteria conversation with pediatric neurosurgeons in Moscow. He provides thereby an often neglected human dimension to science.

In the early 1990s, Oliver Sacks, exercising his gift for seeing latent potential, recognized the possibilities in a neglected paper by Goldberg on the "gradiental approach" to organization of the neocortex (1). Sacks' essay on prematurity in science (2) resonated with a long line of essays on the personal and social cost of uncritical neglect or rejection of new ideas (3).

The creative scientist (like the artist) must walk a narrow ridge. On one side there is the need to accommodate the traditions of the profession in order to survive as a professional, and on the other, there is the need to be free of such social constraints in order to make creative

contributions and prosper as a professional (4). William Wordsworth understood: "Never forget," he wrote, ". . . that every great and original writer, in proportion as he is great and original, must himself create the taste by which he is to be relished"(5).

Going beyond the obvious. In the spirit of Wordsworth, Goldberg's book seeks to create an appreciation for his insight. As often the case, data has emerged that makes his task easier. He begins by seeking to reframe the perennial (and parochial) either-or quarrel about modularity of mind. He notes that while a modularity persists in many ancient parts of the brain, more recently evolved structures—those that collate and integrate the information provided by these modules—possess a density of intrinsic connections that creates a functional "gradiental" continuum. These more recently evolved structures are the frontal lobes, the "organ of civilization" according to some of the founding fathers of neuropsychology such as Ward Halstead (6) and the author's mentor, the great A. R. Luria. The book arrives at a time which for many of us is what teachers sometimes call "the teachable moment." Many of us are ready for Goldberg's ideas.

Goldberg's introduction promises that this book is about a dozen huge themes, in fact everything humans might ever care about. But as it unfolds we learn that everything we might ever care about — what makes us human — is mediated by the frontal lobes. Forgive his enthusiasm. We are on alert that he will be thinking creatively and with interdisciplinary connections at every opportunity. His overview of neurophysiology is straightforward and when arcana of neurophysiology are occasionally introduced and they are illuminating. Details such as “Yakovlevian torque” (the asymmetries in a human brain obvious to neuroanatomists)(7) or “Talairach space” (a template provided by one hemisphere of the brain of a French woman used as a reference point in many recent neuroimaging studies) will provide valuable perspective.

The introduction to the book identifies dozens of subjects that Goldberg would deal with, but its real mission is to evoke a broader appreciation of the once “silent” prefrontal cortex, now quite garrulous. This part of the brain has attracted popularization (see Skoyles and Sagan's *Up from Dragons*)(8) possibly in part because authors are no longer intimidated by the conundrum of a brain contemplating itself.(9) They no longer worry as much about how objective and subjective understanding articulate with each other. There are ways to guard against the retreat from the often overbearing requirements of reason.

The process may defeat common sense, but perhaps uncommon sense will work. Such a perspective is provided by comparisons of systems of likely interconnections and their effects on behavior as revealed in the brains of other species, possibly in concert with a bit of *critical anthropomorphism* (10). This is the perennial allure of ethology. We can stand *slightly* more clearly outside the mentality of our non-human brethren and get at least part of picture. But still, the complexity of the prefrontal cortex might easily exceed our capacity to imagine its potential. In the case of this structure and its

links to the more conservative functions of mind, we must compare members of our own species who for congenital or acquired reasons possess brains which are connected and operate in really different ways.

Goldberg's brief overview of the main architecture of the forebrain is accessible and sufficiently complete to help the novice navigate the rest of the text. Some structures or systems (such as the limbic system), however, seem written off too easily and others (amygdala) are assigned overly broad roles. There is a hint of anatomical imperialism — or at least prefrontal corticocentrism — as parts of the cerebral landscape are claimed to be allied more with one functional area or another, but it *is* a book about the frontal lobes.

Goldberg's Orchestra. The now familiar and still helpful metaphor of “cerebral symphony” is used by Goldberg as he introduces the front rows (the cortex) and the conductor (the frontal lobes). The author develops a rationale for cerebral asymmetry and specialization that goes well beyond that necessitated by early observations of lateralized language skills. He starts down the path of evolution as a source of insight and finds support for the depth of hemispheric differences in some preverbal taxa as far as he goes. But I'd have loved to see him go further. We know now that many species (even my favorite model vertebrate, the lizard) show evidence of functional asymmetry that involves much more basic behavioral patterns (11). Looking at the most conservative available homology of a neurobehavioral pattern is a powerful way of extracting useful information from the seeming chaos of diversity.

Goldberg is not intimidated by the dynamic nature of the brain. He does not limit himself (or us) to a conveniently frozen snapshot of the brain, frozen in time and space. While most authors avoid the confusion implicit in Heraclitian dynamism, Goldberg profitably engages it head on. Only an approach in which the “dynamic, relative, and individualized” nature of cognition is acknowledged can provide a convincing

sense of the depth and potential for enhancing understanding by studying (for example) cortical asymmetry. His leverage is provided by work on disorders that lead to impaired recognition of faces (prosopagnosia) or melodies (amusia). In both cases, *unfamiliar* experience is processed predominantly with the right hemisphere, but *familiar* experiences get proportionally more attention from the left hemisphere – what the author describes as the “novelty–routinization distinction.” The dynamics of this shift in cerebral activity as experiences become more familiar is emerging, Goldberg tells us, thanks to neuroimaging studies, and he provides a couple of compelling examples. Before a reader can fall victim to the glib left-right generalizations common in popular literature, Goldberg reminds us that in reality “each cerebral hemisphere is involved in all the cognitive processes, but [it is their] *relative degree of involvement* [that] varies according to the novelty–routinization principle.”

I use the acronym DEEP to help my beginning ethology students remember the domains of biology whose levels of resolution, questions, and methods so often provide converging insights: Development, Ecology, Evolution, and Physiology. These fields, identified over 50 years ago by Tinbergen (12) as the pillars of ethology, can richly inform each other’s questions, exchange techniques, and help interpret each other’s answers. Their consilience – converging insights– confers confidence in the conceptions of nature that emerge. I felt enriched by Goldberg’s developmental sensibilities, but again wished for more evolution. The facts of routinization beg to be viewed jointly with phenomena such as categorization (how are more or less familiar stimuli recognized?) automatization (how is cerebral control shifted from responses requiring cognitive effort to those that may be wholly automatic?), and the evolution of fixed action patterns (how are reflexes forged into species-typical motor programs?). By way of contrast, it would be exciting to explore ritualization (how fragments

of autonomic reflexes or reflexive action patterns become transformed in signals under conscious control). This would be particularly interesting given that his thinking gravitates toward questions about how nature “splits” (rather than “assembles”) mental functions into specific cognitive operations. Goldberg cannot be faulted here —there’s not much good data for him to work with— but simply asking the questions in the context he creates will create an atmosphere conducive to a broader engagement of these fascinating problems.

Gradients. Goldberg’s introduction to the cortex also ushers in his concept of “cognitive gradient.” As opposed to the relative separation of primary and secondary modality-specific components of the neocortex, a tertiary level (which includes the prefrontal cortex) appears to integrate the modalities. But further, after considering as a whole the pattern of deficits following damage to adjacent cortical sites, Goldberg believes that cognition, rather than being located in encapsulated modules, is distributed throughout the cortex in a graduated and continuous manner.

As an interesting personal aside, Goldberg also reviews the origin of his idea as an organizational tool for his school notes about neuropsychiatric syndromes. This was almost 15 years before he was aware of its conceptual and explanatory value. It was, when he first suggested it to colleagues, perceived as a challenge to the well-established doctrine of cerebral modularity and was thus largely neglected. This happened in spite of the fact that his idea did not need to overturn the modularity doctrine, but only to build on it – his theory was characteristic only of recently evolved structures. In his exegesis of the gradiental theory he warily (and wisely) speaks of proximity to the truth rather than the truth itself. And proximities are also the key to his theory of gradiental organization. It is energized by the observations that mental representations of things are not modular. He draws on his understanding of associative agnosias. In such disorders, things

appear to be represented as a distributed network touching on the multiple sensory elements that converge on it, and one path to object recognition might be impaired while others remain intact.

What's New? The relationship of the organism to novelty is arguably the front-line of adaptation, and Goldberg explores the relationship of the frontal lobes to novel experiences with overdue attention to the importance of laterality. Important impetus comes from studies demonstrating that when new information is assimilated, "the locus of cognitive control shifts from the right hemisphere to the left hemisphere, and from the frontal to the posterior parts of the cortex" (p71). The complexities of decision-making attributable to the diversity of variables that come into play are engaged in specific ways by different parts of the prefrontal cortex. Goldberg notes with regret that the Western cultural tradition emphasizes *veridical* decision making (one "true" response) to the exclusion of *actor-centered* (individualized) adaptive decision making. This latter cultural style is largely abandoned, forcing each individual to learn (or not) as best they can by themselves. Goldberg does not develop the history of this theme but I'm not surprised that with Luria and Vygotsky in his scholarly genealogy, he would develop such an attitude. Regrettably, at the same moment that more and more responsibility for education is relinquished by families to the establishment, this attitude is not yet affecting our economically plagued system where the future of our children is entrusted to budget bean-counters and the lowest bidders. We have long been aware of the critical importance of the environment of early brain development, but more recently we have learned of the dramatic growth spurt in the frontal lobes of teenagers (13). The terrible cost of neglecting their needs is now emerging (14).

The extraordinary breadth of what might be regarded as normal is presented by Goldberg in a rare and welcome digression into the variabil-

ity of brains and the origin of individual differences. This is an emergent field of psychology that resonates with the integrative ethos of DEEP ethology –might, for example, variations represent in some measure a balanced polymorphism? Also, the context-dependent (or -independent) decision making strategies (and the sex differences Goldberg describes in their deployment) underscores the utility of an ecological approach to behavior, with its optimizing (cost-benefit) and systems approach. Could context-independent decisions represent a response based on an a kind of "average" –an optimum derived from a more-or-less extensive repertoire of alternatives? In such a case, the optimum would likely change gradually as new possibilities are assimilated – for example as our life-experiences accumulate and potential for specific paths of action develop (think of puberty). The alternative is skewered by the old joke about the a statistician observing two colleagues shooting at a target: one shot was a foot too high, the other a foot too low: the statistician responded enthusiastically: "bull's eye!"

Context-independent decisions are informed by less experience and thus they work well when confronted with unique situations with little or no precedent to rely on for decision guidelines. In reaching for biological relevance, Goldberg appreciates the stability of the environment in influencing the choice of a strategy a person might employ. To my mind, this recalls the modulating effects of subclinical stress. Once evoked by (for example) an unstable or unpredictable environment, the cognitive effects of stress can (in moderation) facilitate more creative cognitive processing of problems (15). Another consideration that might be included is the real or perceived biological relevance of the decision and the rules for how situations are relegated to larger or smaller categories, but exploring these aspects would take an extensive comparative data base.

In males and females, both context-dependent and context independent decision

making strategies exist and there is significant flexibility in their implementation. But when males or females have damaged frontal lobes, this flexibility is lost in a way that reveals significant differences between the sexes. In general, Goldberg believes, left-right differences are more distinct in males than in females, but front-to-back differences are better articulated in the female brain than in the male –and not just quantitatively, but *qualitatively* (p.97).

Hemispheres also differ in their relation to familiar versus novel stimuli – Goldberg links the left hemisphere to routine and the right hemisphere to novelty. He also finds some associations in responsiveness with left/right handedness where many other have failed. He attributes this to his unique approach to testing for cognitive styles rather than abilities. Left-handers seem to be more acutely sensitive and responsive to novelty than right handers. Could this be, he asks, an evolutionarily-based adaptive balance between tendencies for innovation versus conservatism in cognitive style?

The Bottleneck. The frontal lobes are limited by an especially vulnerable bottleneck through which information must flow if it is to be fully processed by the unique competencies of its dorsolateral and orbitofrontal areas. The dorsolateral frontal lobes energizes “drive” and the expression of “personality” as well as subjective and affective experience (famously impaired by lobotomy or cingulotomy). It is complemented by the orbitofrontal area’s impulse control. In the coordinated work of these areas we may find the competence for a meaningful theory of mind, the relationship between *I* and *thou*, and the emotional “coloring” Goethe’s Faust may have been referring to when he compared “the grayness of theory” to the “green and golden colors of life (16).

These areas are plagued with a low “functional breakdown threshold” (p115) probably attributable to the Jacksonian principle that the most phylogenetically young areas are the first to be afflicted by –or the least resilient to– stress (17). Indeed, acute stress can effectively

take the prefrontal cortex “off-line” allowing the organism to “default” to more conservative, phylogenetically older mechanisms that evoke instinctive or highly automatized action patterns (18).

Goldberg also outlines key elements of a dorsolateral syndrome of diminished responsiveness and accompanying inertias of initiation and termination of behavior. For example, diminished responsiveness is evident in a fundamental indifference to circumstances, including pain. Apparently, even when highly aversive sensory experiences fail to gain access to the frontal lobes, the affective response is forestalled and the behavioral and physiological sense of suffering diminished or absent. “Inertia” best describes the extraordinary difficulty getting a dorsolateral patient to initiate specific actions or to terminate them once begun. Activities do not just go on and on because the inability to terminate actions is accompanied by a perseveration of key elements of the activity. But it is a perseveration that is remarkably vulnerable to incidental distractions, a phenomenon known as *field-dependency* (p125-126). Examples include “echolalia” and “echopraxia” –the imitations of speech or actions expressed around the patient.

At this point in the book, Goldberg’s narrative skill with selected case studies rescues the clinical descriptions and technical language. Goldberg –the student of brain damage– develops a personal as well as clinical connection to a brain-damaged student, and our understanding as well as his profit thereby.

Goldberg now steers into the more familiar concerns of attention deficit hyperactivity disorder (ADHD) and obsessive-compulsive disorder (OCD). He reviews some of the diagnostic tools and then concludes this chapter with an account of the mysteries of anosognosia, involving a patient’s inability to perceive their own debilities, most pronounced with right hemisphere damage.

The subsequent discussion of orbitofrontal syndromes is linked to a digression into the ap-

parent ethical/legal implications. A missed opportunity here –and one that Goldberg is probably highly prepared to discuss, considering his earlier comments on anosognosia, is to further explore the neglected concept of “insight” in the clinical sense of involving awareness of one’s disorder and/or its social consequences and/or the value of treatment. It is clearly a multidimensional problem of particular poignancy in schizophrenia, but one which may be crucial for effective patient compliance. The small amount of work to date has not associated it with neurocognitive functioning and the forebrain, although poor insight *is* related to poor social skills (19)

Personality and pathology. “If the dorso-lateral patients are in a sense devoid of personality, then orbitofrontal patients are conspicuous for their ‘immature’ personality” (p140). Goldberg’s review leads to the question, “Is it possible that social stimulation is to the frontal cortex what visual stimulation is to the development of the occipital cortex?” And beyond that, might and impaired prefrontal cortex lead to moral agnosias akin to the object agnosias of posterior association cortex dysfunction? He goes on to describe a “pseudopsychopathy” associated with damage to the orbital surface of the frontal lobes in which urges for instant gratification are unrestrained by fear of punishment. Goldberg has relentlessly emphasized frontal lobe function, but he has also detected an unexpected path to disorders such as pseudopsychopathy: the less obvious upper brain-stem damage that he believes is more common than generally believed. This is a possible consequence of closed head injuries, and should in his view receive much more attention from clinicians. In the late 1980s, Goldberg described a “reticulofrontal disconnection syndrome” in which such injuries could lead to frontal lobe syndromes due to the interruption of critical pathways.

The orbitofrontal syndrome of emotional disinhibition involves impaired tolerance for delayed gratification, very diminished impulse

control, and no evidence of foresight or concern about the consequences of one’s actions. The legal implications are provocative. We work hard to get inside the minds of people who have transgressed: premeditation, malicious intent, response to provocation, diminished capacity (20). While some patients have no understanding of right or wrong (think of Shakespeare’s Richard III), others may be quite knowledgeable about right and wrong, and *still* be unable to translate their abstract knowledge into action. Goldberg suggests a new legal construct: “inability to guide one’s behavior despite the availability of requisite knowledge” (p150).

An extended discussion of the varieties of congenital or acquired disconnects that can compromise or distort forebrain function is introduced with a case study of a highly successful, entrepreneur and executive with an apparent reticulofrontal disconnection syndrome. The patient is given to perseverative behavior leading to repetitive stereotypies and is highly field-dependent (sensitive to context). CAT scans revealed no frontal lobe damage, but there were temporoparietal problems. Not the classic *horizontal* “disconnection syndrome” between adjacent cortical regions described by Norman Geschwind in the 1960s, but a *vertical* disconnect. Could there be a dysfunction of that key modulator of frontal lobe function, the mesocortical dopamine system? This system, which originates in the ventral tegmental area of the brain stem can be selectively activated by stress (21).

Schizophrenia appears to involve a developmental or congenital problem more than a traumatic or acquired disconnection and discussions of dopamine connections invite further consideration of this devastating disorder. While it is not clear if the dopamine connection is a primary or secondary element, it *is* clear that traumatic brain injury may play a far more important role than expected. ADD and ADHD, as well as Tourette’s syndrome are presented in terms of connectivity. These discussions were illustrated with compassionately

presented case studies from Goldberg's experience. These narratives provided key insights that a clinical account could not have transmitted, and were communicated in a non-judgmental way that made me feel like a privileged colleague of Goldberg's.

But as a colleague, I'd plead for Goldberg too more fully address the rare but fascinating highly specific lesion-induced dysfunctions ("strong dissociations") that are (too) often taken as evidence for highly specific functional modules in the brain. The interpretation of such disorders are complicated by individual differences in cognitive styles, but they may well remain important chinks in the almost seamless armor surrounding brain function. True, some authors engage in a self-aggrandizing rush to overgeneralize specific rare cases, but assembling enough of these may well lead to new insights. As Joni Mitchell put it so clearly in 1970, "Don't know what you've got 'til it's gone" (22).

While some of the book's quirks are a welcome counterpoint to parochialism, others (for example likening brain functions to social forces) are weaker and undermine the book's authority. Goldberg is inspired by the highly productive reciprocity of brain science and artificial intelligence, but the idea that leadership of the "executive" functions of the cortex is analogous to leadership in history is premature at best. There is, of course a co-evolutionary spiral –the "runaway brain" metaphor in which environmental changes created by brainpower alter the empowering brain's own epigenetic landscape – that is, the brain creates its own selection pressures. This may or may not irretrievably damn the descendants of the "noble savage" but it certainly keeps things interesting. Another overwrought metaphor is that of the orchestra and conductor when he introduces the idea of "musical chairs."

News You can Use. As the book steers into its home stretch, Goldberg seeks to put cognitive impairment in *practical* perspective. Traditional medicine's abiding concern with life-

saving measures and attention-demanding abnormalities and dysfunctions has masked mild or subclinical impairments or dementias that may profoundly affect the *quality* of life. In emphasizing prevention over treatment, Goldberg suggests we cultivate a "cognotropic pharmacology." It has begun. Subclinical structural brain disease (SSBD) attributable to developmental changes (including those of senescence), or trauma (even when mild), or disease might well respond to "cognotropic" drugs that enhance the action of various neurotransmitters such as acetylcholine, dopamine, glutamate, or serotonin. The optimization of effects, balancing costs and benefits again, could quickly lead one into a wilderness of conflicting collateral effects but the ideology is in place and growing. With all that said, Goldberg is nevertheless disdainful of the "take-a-pill" mentality, and would rather see us expend personal effort. In that respect he compares exercising the brain to exercising the body as a path to a more fit constitution. Goldberg recruits the usual suspects (the "Nun's Study, the London taxi drivers) to support his sense that "cognitive fitness" is the next big thing. "Use it or lose it" is not a simplistic analogy to him, In fact, he recommends a balanced regimen in general and a specific problem-oriented regimen for certain patients in his own practice. He is encouraged that the temporary diminution of cognitive function in many patients when "on vacation" from treatment disappears when they resume the program.

Goldberg concludes *The Executive Brain* with a brief reprise of his "gradiental" principle. The "massive continuous interactions," of the brain are not well served by the mere hypertrophy of more ancient areas (such as the thalamus). Such modules seem to have exhausted their adaptive potential while the large numbers of heavily interconnected sites of the neocortex that enjoy a "dynamic topology" can allow new functional roles for cortical regions to emerge. This property is in principle much better suited to solve the adaptive problems that

inevitably present themselves to animals who have painted themselves into a more complex niche.

Goldberg is unable to resist searching for broad principles that might converge with his analysis of brain evolution. He understands consilience – the power of corroboration from different domains of understanding. He believes (correctly, I think) that behavior is the brain writ large. Sometimes too large – for example, to Goldberg’s thinking, the changes in eastern and western Europe since the collapse of the Soviet Union resonate with the evolutionary changes in the brain. The resurgence of ancient ethnic languages in the smaller more fluid political entities that have emerged in recent decades, suggests to Goldberg a movement towards a post-modern rather than premodern condition. The direction of geopolitical change as he sees it strongly recalls the manner in which the brain solved its problems with “distributed responsibilities and local autonomy.” One in which smaller, flexible units, like those of the neocortex, are more able to solve wholly new adaptive problems. These speculations are not without *some* support, but such imaginative suggestions require more than footnotes. He also finds analogies in digital technologies: he finds that internet search engines resemble “digital frontal lobes” in that they have no answers but provide vast overviews and rapid access to information.

Goldberg’s relentless interdisciplinarity has sometimes led him onto shaky ground, but he is wisely modest about his playful if not provocative speculations. I would not be surprised if many of them did not lead to much more serious scholarship that is likely to illuminate vexing issues and concerns from computer science to political science. His effort is, in the end, a great collection of well-framed and organized personal and clinical observations that provide an engaging, informative, and often compelling overview of the frontal lobes, not only as the structure that enables our humanity, but as a metaphor that may help us cope with the com-

plexity in which we are forever inextricably enmeshed.

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NOTES

1. Goldberg, E. 1989. Gradiant approach to neocortical functional organization. *J. Clin. Exp. Neuropsychol.* 11(4):489-517.
2. Sacks, O. W. 1996. Scotoma: Forgetting and neglect in science. In R.B. Silver (editor) *Hidden Histories of Science*. New York, New York Review of Books. Pp. 141-187.
3. Stent, G. S. 1972. Prematurity and uniqueness in scientific discovery. *Scientific American* 227(6):84_93.
4. Hegel once said “Thus to be independent of public opinion is the first formal condition of achieving anything great or rational whether in life or in science” (*The Philosophy of Right*, 1821).
5. William Wordsworth’s Letter to Lady Beaumont, 21 May 1807, in E. de Selincourt (editor) *Letters of William and Dorothy Wordsworth* vol. 2; revised by M. Moorman, 1969.
6. Ward Halstead, one of the founders of modern neuropsychology concluded his book, *Brain and Intelligence*, with “The frontal lobes, long regarded as silent areas, are the portions of the brain most essential to biological intelligence. They are the organs of civilization—the basis of man’s despair and his hope for the future” (1947:149).
7. “Right frontal lobe is wider than, and protrudes over, the left frontal lobe. The left occipital lobe is wider than, and protrudes over, the right occipital lobe” (Goldberg p41).
8. Skoyles, John R. and Dorian Sagan. *Up from Dragons: The Evolution of Human Intelli-*

- gence, New York, McGraw-Hill, 2002; reviewed in *Human Nature Review* 3:142-148.]
9. Lyon, G. R., & Rumsey, J. M., (1996). *Neuroimaging*. Baltimore, MD: Paul H. Brookes Publishing, Co.
 10. critical anthropomorphism is an ethologically informed source of hypotheses about the causes and consequences of behavior in other organisms. Since the minds of other taxa (indeed other humans) are ultimately unknowable, it builds on shared characteristics while remaining to the often profound differences. See Burghardt, G. M. Cognitive ethology and critical anthropomorphism: a snake with two heads and hognose snakes that play dead. In: *Cognitive ethology: The Minds of Other Animals* (Ed. by C. A. Ristau), pp. 53-90. San Francisco: Erlbaum Press, 1991.
 11. Bisazza A., Rogers L. J., Vallortigara G. 1998. The origins of cerebral asymmetry: a review of evidence of behavioural and brain lateralization in fishes, reptiles and amphibians. *Neurosci Biobehav Rev.* 22(3):411-426. And Vallortigara G, Rogers LJ, Bisazza A. 1999. Possible evolutionary origins of cognitive brain lateralization. *Brain Res Brain Res Rev.* 30(2):164-175.
 12. Tinbergen, N. 1951. *The study of instinct*. Oxford, Clarendon Press.
 13. Sowell, E. R., Thompson, P. M., Holmes, C. J. Jernigan, T. L. & Toga, A. W. (1999) In vivo evidence for post-adolescent brain maturation in frontal and striatal regions. *Nature: Neuroscience* 2(10): 859 - 861. And see The National Research Council's 1999 Forum on Adolescence : *Adolescent Development and the Biology of Puberty*, National Academy Press, 1999.
 14. The International Justice Project <<http://www.internationaljusticeproject.org/>> has recently highlighted the legal implications of changes in teenage brains.
 15. Greenberg, N. The Neuroethology of Creativity. in, *The Child's Right to Play: A Global Approach*. Rhonda Clements & Leah Fiorentino, editors. Greenwood Press, Westport CT (in press); Greenberg, N., J. A. Carr, & C. H. Summers. 2002. Causes and consequences of the stress response. *Integrative and Comparative Biology (American Zoologist)* 42(3):508-516.
 16. *Grau, teurer Freund, is alle Theorie, Und grun des Lebens goldner Baum.* (Goethe's Faust quoted by Oliver Sacks in his *The Man Who Mistook His Wife for a Hat* (1985), on the grayness of theory versus the green and golden colors of life)
 17. Hughlings Jackson's "law of evolution and devolution."
 18. Taking "thinking" off-line is a response which can save potentially critical milliseconds; nicely covered in recent reviews by Amy Arnsten (Arnsten, AFT 1998. Catecholamine modulation of prefrontal cortical cognitive function. *Trends in Cognitive Sciences.* 2(11): 436-447. Arnsten, A. F. T. 2000. Through the looking glass: Differential noradrenergic modulation of prefrontal cortical function. *Neural plasticity.* 7(1-2): 133-146.]
 19. Several authors found "a relationship between ratings of poor insight and a psychotic (vs. mood) diagnosis, increased psychiatric symptoms, [led to] poorer social skills, and negative medication attitudes, [but] . . . no relationship was found between level of insight and age, gender, education level, neurocognitive deficits . . ." (Goldberg R. W., Green-Paden, L. D., Lehman, A. F., Gold, J. M. 2001. Correlates of insight in serious mental illness. *J Nerv Ment Dis.* 189(3):137-145). In another paper, patient unawareness of illness and neuropsychological tests of frontal lobe function in subjects with schizophrenia and bipolar disorder (BD) with psychotic features" were studied. Three insight dimensions (awareness of mental disorder, awareness of social consequences of mental disorder, and awareness of the benefits of medication) do not appear

to be associated with frontal impairment, as measured by the test these authors used (Arduini, L., Kalyvoka, A., Stratta, P., Rinaldi, O., Daneluzzo, E., Rossi, A. 2003. Insight and neuropsychological function in patients with schizophrenia and bipolar disorder with psychotic features. *Can J Psychiatry*. 48(5):338-341).

20. "Where a person kills or is a party to the killing of another, he shall not be convicted of murder if he was suffering from such abnormality of mind (whether arising from a condition of arrested or retarded development of mind or any inherent causes of induced by disease or injury) as substantially impaired his mental responsibility for his acts and omission in doing or being a party to the killing." (Lacey and Wells, 1998). "To prove diminished responsibility medical evidence showing abnormality of mind is essential, as was shown in *Dix* (1981) 74 Cr App R 306. Section 2 does not ask for proof that the abnormality of mind caused the killing, only that the defendant was suffering abnormality of mind to such a degree that their mental responsibility for their actions

was impaired (Allen, 1996). The phrase "abnormality of mind" was defined in *Byrne* [1960] 2 QB 396, as a state of mind that is so different from an ordinary person that a reasonable man would find it abnormal. This means that any attribute that might be experienced by the reasonable man, such as hatred, rage or jealousy, alcohol or drugs, is not classed as producing an abnormality of mind. However, there have been cases where rage or jealousy have produced a s. 2 verdict - that is, diminished responsibility has been proven."

<http://web.ukonline.co.uk/ruth.buddell/chapter1.htm>.

21. Thierry, A. M., Tassin, J. P., Blanc, G. & Glowinski, J. 1976. Selective activation of the mesocortical DA system by stress. *Nature* 263:242-244. (cited by Bowers, Zacharko, & Anisman. 1987)
22. "Big Yellow Taxi, 1970."
23. I thank several friends and colleagues for tempering my enthusiasms and excesses and for helpful suggestions of both substance and clarity. Particular thanks to Gordon Burghardt and Sandra Leach.