The Adolescent Brain: Why It Is More Important Than Ever To Protect Our Adolescents

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Adolescence has classically been viewed as a psycho-developmental stage. Simply speaking, it has been analyzed as a classical conflict-ridden struggle between the adolescent’s independent strivings on the one hand and dependency needs on the other. The same individual complaining about the unfairness of a curfew wants to be tucked in at night. The adolescent can be best conceived of as having one foot out the door while simultaneously keeping his/her other foot firmly planted at home. We have all seen this paradox, scratch our heads and pray that this stage will run its course as quickly as possible. “Drugs, sex and rock-and-roll” are inevitable way stations on the path of adolescence. Sadly, much of the harm reduction movement espouses the same ideology only to misinform the public and place our children in harm’s way.

What if the psycho-developmental model of adolescence reflected the best thinking and neuroscience sophistication at the time but may not be relevant now? We are reminded of Sigmund Freud’s suggestion that chemical biological discoveries would alter his psychoanalytic theories of the mind. The past two decades have provided an explosion of brain imaging technology including Positron Emission Tomography (PET), Single Photon Emission Computerized Tomography (SPECT), and Functional Magnetic Resonance Imaging (fMRI). We no longer have to “guess” at the underpinnings of behavior, thought and affect. The functional activity of brain regions can now be linked in real time with clinical observation. Even more important, the ability to link electroencephalographic data with functional imaging, we have known for decades that the brain is an electrical and chemical organ. But we have only begun to investigate the link between the two or fully understand the sophisticated control systems of the central nervous system (CNS).

We have come to that historical place that Freud suggested. CNS function and, therefore, mental state activity can directly be traced to brain activity. That is not meant to imply that psychological processes do not exist. They certainly do and, if anything, become more important as we understand the valuable impact of psychotherapy. Imaging studies have begun to suggest that talking and behavioral therapies may lead to brain change. This is no surprise, for we have come to understand that the process of learning involves structural (at a synaptic or inter-neuronal level) and neurochemical change.

So what does this have to do with our teenage kids? Recent brain discoveries are suggesting that we need to consider the adolescent stage of development as analogous to the puppy stage of the family dog. Those of us familiar with the trials and tribulations of raising a puppy can fully appreciate the difficulties of the puppy stage. Do we believe that the puppy exits this stage into mature “dog-hood” as a function of all that we have trained and taught our pet? Probably not. Instead, we assume that our puppy has finally matured to dog status. Our guidance and training of this animal has been valuable, but the progression to a mature pet required the establishment of mature connections and function of the animal’s CNS. Or consider the human organism’s maturation from infant to toddler to young child. Again, our input is invaluable, but each Piaget-based developmental step requires adequate neuronal maturity and function. This paper suggests that the same degree of supervision and protection that we require for the care of our pet puppy or our infant/toddler/young child must be applied to our adolescents, for the adolescent brain is far from mature.

We had all believed that the human brain reached maturity by early adolescence, if not at the time of puberty. Historically, anatomic studies of the preadolescent’s brain demonstrated that the 12 year old brain was full-grown in size. Even Piaget, the champion of developmental stages, suggested that the highest point of cognitive maturity occurred at about age 12 when the level of formal operations appeared. This belief system provided support for the psychological understanding of adolescent behavior. If the adolescent’s brain was ready to enter into the adult world, then all the vicissitudes of adolescent storm and drang can be best explained by psychodynamic postulates. But what if we were mistaken, and the brain of the teenager is not fully formed? If true, then we can only expect the adolescent (brain) to perform at a level equivalent to what it is capable of and must protect what function it is incapable of.

Recent advances in developmental neurobiology have demonstrated that the human brain does not fully mature until the late teens or mid to late twenties! That does not mean to suggest that the entire CNS is immature before this period. On the contrary, large portions of the brain are fully mature at a much earlier age. The newborn starts life with basic brain-derived functions: the ability to breathe, to eat (suckle), eliminate, and to some primitive degree experience the multisensory environment. One can almost visualize progressive neuronal maturation as the once helpless newborn develops locomotion, communication, and basic logical capabilities as the milestones of childhood are sequentially attained. This is where the adolescent story gets dicey. Like “judging a book by its cover”, the typical adolescent looks pretty capable from a functional perspective. That is, he/she has mastered language skills, exhibits adequate fine and coarse motor coordination, seems to be able to use logic and reason (our misperception), has advanced in school, seems to have developed interpersonal skills, can self feed (even it means McDonalds), and self protect if threatened. What if the “book” is not at all congruent with the “cover”? What if some chapters of this book have matured, leaving immature chapters still in a growth phase? This is exactly the adolescent neurodevelopmental scenario.
It appears that the teenage brain is almost fully matured. However, it is lacking a mature frontal lobe, more specifically the prefrontal cortex (PFC). The PFC is critical for planning, evaluation of the outcome of behavior, delaying gratification, and, most importantly, controlling basic drives. The PFC tries to make sense out of the complex multisensory information that reaches more primitive brain centers. The PFC is a reasoning censor that controls behavior so that it approaches human acceptability similar to the governor of a truck engine preventing extensive wear from traveling at too high a speed. The PFC allows for ego and superego development.

Adolescent brain regions that have attained a significant degree of maturity include motor cortex, sensory cortex, and language/thinking cortex (note that this does not intuit logical processes). The subcortical regions of the adolescent CNS have fully matured. These regions are responsible for basic life functions like breathing, heart rate control, blood pressure, procreation and flight/flight mechanisms. The Limbic System and its connections form a core component of these subcortical processes. Basic drives originate from this complicated area. The drives for “drugs, sex and rock-and-roll” stem from Limbic anatomy. This is a brain driven by a region that is seeking stimulation, excitement, and novelty. Living on the edge is the norm for the adolescent brain. In the fully formed adult brain the Frontal Cortex (and most importantly the PFC) serves to regulate the subcortical basic drive regions. Like past U.S. President Jimmy Carter, adults can have lustful thoughts without acting on them. The teenage brain, flooded with rap music, blatant violence and sexuality in the media, and the uncertainties of life in the modern world finds itself driven to “act out” without an adequate control governor. Add to this the activating properties of sex hormones blossoming at this time, and you have a graphic picture of what is the normal adolescent phase. “Drugs, sex and rock-and-roll” and out of control teenage behaviors can be the end result. We will discuss our responsibilities as grown-ups later in this paper.

Therefore, it is no surprise to find the adolescent ill prepared to face the substance abuse peer pressures of their environment. The adolescent is naturally driven towards adventure and excitement, and “pushing the envelope” can be the norm. One can envision the brain’s pleasure centers crying out for stimulation and reinforcement. “Gimme, gimme, gimme, more, more, more” become their marching cry. And because they are not known to think through actions or anticipate problematic repercussions of behavior, the adolescent modus operandi is very similar to the core component of drug dependency, the persistent use of a substance despite untoward social consequences.

It becomes apparent that the adolescent brain is an addiction accident waiting to happen. The risks are immeasurably increased by what we have learned from recent advances in the neurobiology of addiction. Drug dependence and tolerance appear to represent morphological and biochemical changes in the brain’s pleasure system (nucleus accumbens and ventral tegmentum). These changes seem to follow a conditioned learning paradigm and help explain the persistent drive to abuse and the miserable remission rates.

Animal studies have helped explain the adolescent predisposition to addiction and why drugs of abuse affect the immature brain differently than the fully formed adult brain. Adolescent rats given nicotine will subsequently seek out more nicotine than rats initially exposed to this substance in rat adulthood. Because this species does not think or reason, we must assume that the rat’s immature brain is the driving force for the escalated use. This has been replicated in rat cocaine experiments as well.

Exposure in adolescence is not a prerequisite for substance dependency. Initial drug abuse in adulthood certainly leads to dependence. Genetic predisposition may play a critical role in some adults, but there is no doubt that drugs of abuse interact with the brain’s pleasure system and reprogram these centers so that they are directed towards repeated drug seeking. The addict’s brain has been essentially hijacked, a commandeering of the brain’s natural reward circuits. The cortex does not escape this process unscathed. There is evidence that persistent neurochemical stimulation (probably involving dopamine) during persistent drug abuse not only recruits and brainwashes primitive brain regions (limbic system) along with the cortex (specifically the PFC), but implants drug abuse cues (people, places, things, pleasure response, etc.) in a complex, reverberating neuroanatomic circuit that loops from primitive limbic areas to prefrontal and orbitofrontal cortex, resulting in the obsessive drive to score drugs. Interestingly, this loop is similar to the neuroanatomic circuitry that has been suggested in obsessive compulsive disorder. When deprived of the drug, even after the withdrawal period, the addicted brain is programmed to return to active abuse when external stimuli trigger this circuitry. The mature PFC has trouble controlling this process, resulting in impulsive problematic decision making and ongoing cycles of relapsing drug abuse.

Adolescent behavior with its plethora of impulsive acting out, heightened emotional reactivity, risk-taking behavior, and seemingly irrational cognition now makes total sense, given our new found knowledge of the adolescent brain. We have come to accept the behavior of the puppy dog or the terrible twos of our toddler as expected, albeit challenging, behaviors. As parents of the child or owner of the puppy, we implicitly assume that this behavior is “developmentally” appropriate because of the maturity level of the organism’s nervous system. Such is the case for the adolescent. He/she is doing the best they can, given their fully mature limbic drive system and their immature developmentally wanting cortical regulatory centers. It is not until the extensive neuronal pruning of inefficient synaptic circuits and growth and mature connectivity of cortical circuitry that the post adolescent brain welcomes adulthood. These changes may not fully appear until the mid twenties!

Historically, parents and social policy developers do not hesitate to protect the best interests of the child. The polio epidemic of the 1950s is a perfect example. When it became clear that the child’s immune
system required help in fighting off the polio virus, an effective immunization program ensued. In addition, parents of a crawling one year old do not hesitate to "baby-safe" all their cabinets to prevent toxic substances from being available to a child that doesn't know better. We do all of this because we recognize that the child’s brain requires that grownups proactively protect the child. Based on the data presented in this paper, it becomes eminently clear that we must step in and protect the adolescent and, at times, the young adult. This means establishing rigid familial controls over curfew, peer contact, internet, and television exposure. The multimedia explosion has its wonderment, but it comes at a terrible price. Reality television, internet pornography, and the ubiquitous exposure to traumatic images and events in the media are passively received by an adolescent brain that does not have the adult (i.e. cortical) filtering capabilities.

This brings us to the harm reduction movement. The idea of reducing harm is appealing to all caring individuals. The basic message of this movement is: if our children are going to use illicit drugs regardless of what we do, why not limit the danger of drug abuse by educating them about abusing drugs? For the most part, the concept of harm reduction has been espoused by caring and well meaning adults. However, this approach totally bypasses the value of prevention. It also enables our children to abuse because it instills a self-fulfilling notion about the inevitability of drug abuse. This movement has resulted in the development of "injection rooms" for the administration of heroin, leading some countries to even suggest government controlled distribution of heroin. Comic book-like pamphlets providing a self help guide to the “safe” use of crack cocaine have surfaced in schools. The attempt to legalize a variety of illicit drugs has been another outgrowth of the “harm reduction” movement.

Harm reduction is an unfortunate distraction from our mandate as responsible, concerned adult citizens of the world. We must protect our children from a world that is ever more complex and threatening. The advent of the internet has further compromised our ability to shield our offspring from the "things that go bump in the night". We must pursue public policy to limit exposure to all aspects of illicit drugs. It is our responsibility. Our children determine our destiny.

References