"Minding The Brain": A Developmental Neurobiological Model for Substance Abuse Treatment in Emerging Adults

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Prior to the turn of the 21st century, we lacked a theoretical framework for distinguishing 18 to 29 year-olds from those who are younger and older. This lack of developmental theory resulted in scant scientific research describing the mental health issues that young people in this age group face. Not surprisingly, we have very few treatment models designed to fit their mental health needs. Because substance use disorders are common in this age group, debilitating during years when much growth is expected, and an unfortunate precipitant of accidents and death, the absence of treatment models designed to fit this specific age group is particularly alarming. However, recent advances in developmental theory and neurobiological research present an opportunity to design developmentally-sensitive models for the treatment of substance abuse disorders in 18 to 29 year-olds.

The objective of this article is to introduce The Developmental Neurobiological Model for substance abuse treatment in emerging adults. Emerging adulthood (ages 18 to 29) is a transforming neurobiological and developmental maturational window during which individuals are challenged to negotiate new social prescriptions affecting the personal foundation for separateness, identity and self-integration, and attachment patterns. This is occurring at a time when brain maturation and its neurobiological underpinnings may be in consonance with or at odds with such growth.

This article introduces a therapeutic model for the treatment of substance abuse in emerging adults informed by developmental psychology, attachment theory and research on neurobiological maturation. The model harnesses the brain's neuroplastic capacity during this period by targeting psychotherapeutic, psychosocial and neurobiological interventions towards crucial brain networks that are in the process of developmental maturation but have been aborted and/or distorted by substance abuse. These interventions facilitate neural network maturation in the service of fostering and reinforcing self-mastery and healthy functioning in the emerging adult.

Emerging adulthood as a distinct phase of development

Arnett (2000) introduced the term emerging adulthood to identify the developmental phase in persons ages 18-29 years. This developmental phase, according to Arnett (2004), is characterized by: 1) *identity exploration,* where one's sense of self and self-identification in major life areas such as love, work and world perspective is refined and redefined; 2) *generalized instability* in all areas of life with uncertainty of future possibilities and potential life paths; 3) *a state of in-between* adolescence and adulthood; 4) *self-focus* with a shift toward greater individual identity, personal power, self-regulation and self-agency; and 5) *possibilities and risk*s with risk factors peaking and biological, psychological and sociocultural influences emerging that may be uniquely destabilizing to this age group.

Tanner's (2006) concept of *recentering* complements Arnett's theory by integrating emerging adulthood into the individual life span, and reframing the concept of transition into adulthood as a three-stage process that involves leaving adolescence, experiencing emerging adulthood, and entering young adulthood. Tanner describes an individualized developmental trajectory by which the emerging adult must: 1) separate from family and form primary attachments with peers and other adults; 2) transition from child and adolescent dependencies to engage with the larger world; 3) consolidate a resilient regard for self and identity as a capable and valued member of society; 4) launch a relatively self-sufficient career and life; and 5) develop effective, goal-directed, self-regulated life skills.

Neuroscience research has shown that normal brain maturation in emerging adults parallels the increasing complexity of these developmental and psychosocial demands. The primary, organizing purpose of brain formation and growth throughout the lifespan is to evolve an increasingly complex and higher-order representation of self and self in relation to the world (Siegel, 1999). Identity formation is a critical biological process for survival and adaptation, and emerging adulthood is a pivotal period in the maturation of attachment patterns (e.g., secure, anxious-avoidant, ambivalent, disorganized), which in turn affect self-integration and emotional regulation. The self does not develop optimally in isolation, but within the context of relationships which provide affirming, soothing and vitalizing functions as well as new learning. Siegel asserted that "human connections shape neural connections." This process can be both aborted and distorted when attachment patterns become organized around substances.

Normal emerging adult brain maturation

Healthy brain maturation is critical to the successful negotiation of the unique developmental tasks of emerging adulthood. Emerging adulthood is a period of marked growth in brain size and functioning, most notably in the prefrontal-thalamic-cerebral cortex region of the brain. The prefrontal cortex is involved in the integration of emotion and cognition, which mediate the control of thought and behavior (Gray et al., 2002). Higher-order cognitive functions include planning, decision-making, reasoning, problem solving, working memory and cognitive and behavioral inhibition (Braver & Barch, 2002; Braver & Bongiolatti, 2002). Schore (2003a) described the prefrontal cortex as the "hierarchical apex" of the limbic system, functioning as the "convergence zone" between the brain's cortex and sub-cortex. Interestingly, a lag period exists between limbic system development, where emotions originate, and prefrontal cortex development, where these emotions are managed. The changing balance between limbic-subcortical functioning and frontal lobe functioning impacts social-emotional processes, self-regulation (e.g., states of tension and motivation/vitalization), behavior (e.g., risk reward decision making and delay of gratification), attachment patterns, and homeostatic regulation of the sympathetic and parasympathetic nervous systems (Schore, 2003a, 2003b).

Advances in brain imaging have revealed that additional synaptic sprouting and pruning occurs during emerging adulthood in brain regions linked to self-regulatory functions, information processing, and logic (Keating, 2004). The speed of neural transmission is an

important factor dependent on synaptic and axonal integrity. Neuron myelination provides this integrity, optimizing the connectivity, efficiency, integrative processing and executive functioning of neuronal pathways (Lenroot, 2007; Giedd, 2008). Frontal cortical and subcortical monoaminergic systems mediate motivation, reward and impulsive behavior (Chambers et al., 2003a). Development of subcortical and cortical projections, and the corpus collosum–which integrates activities of the left and right cerebral hemispheres– helps facilitate socio-emotional processing and emotional regulation (Eluvathingal et al., 2006). Each of these processes is robustly in motion during emerging adulthood.

Substance abuse and the emerging adult brain

Until recently, the paucity of research elucidating the full impact of substance abuse on normal brain development in emerging adulthood has prevented the development of tailored and comprehensive models for substance abuse treatment in this population. The design of treatment models can now be guided by the input of data from risk factor analysis, epidemiology research, and studies examining the impact of substance abuse on development neurobiology.

Risk factors

Many developmental risk factors for substance abuse originate within the socio-emotional context. These include challenges, losses and deficits that may occur in emerging adulthood, including the loss of security and structure provided by family, friends, school and community contexts; threats to self-worth from the pressures of assuming responsibility for life competence; psychosocial-emotional triggers that increase personal vulnerability and associated neural activation; and the neuroplastic substrate of weakened attachment patterns during the search for a peer community or love partner, possibly leading to anxiety and issues surrounding aloneness and identification.

Neurobiological risk factors for substance abuse include genetic factors (Tsuang et al., 1996) such as behavioral disinhibition, which is modulated by prefrontal cortex dysfunction (Tarter et al., 2004; Mezzich et al., 2007, Hicks et al., 2010), and the role of serotinergic function in young adult binge drinking (Herman, 2003). Other genetic-neurobiological risk factors include disorders of attachment and self-regulation originating from trauma, abuse, loss or neglect; chronic pain and medical illness; and pre-existing psychiatric or processing disorders (Khantzian & Albanese, 2009; Hicks et al., 2011). Untreated attention deficit and hyperactivity disorder (ADHD) is also associated with a significantly earlier age of onset of substance abuse (mean age 19 years with ADHD vs. 22 in non-ADHD controls) (Wilens et al., 1997).

Prevalence and age of onset

The results of national surveys conducted by the NSDUH (2008) and CDC (Hingson et al., 2005) have clarified the extent of substance abuse and its consequences in emerging adults. According to this data, 20.7% of all individuals in the U.S. aged 18-25 years currently meet the diagnostic criteria for alcohol or substance abuse or dependence.

The need for a neurodevelopmental treatment approach is underscored by evidence that substance abuse emerging in early adulthood is a consequence of risk continuity from earlier developmental stages and the unique neurologic, cognitive, and social changes that typify this age period. Neuroplasticity greatly contributes to substance abuse vulnerability in young adults (Chambers et al., 2003b), and is reflected by the median age of onset of alcohol use disorders of 20 years (Kalaydjian et al., 2009) and by the age of onset before 20 years in most adults with a substance use disorder (Chambers et al. 2003b).

Impact of substance use disorders on the maturing brain

A substantial body of evidence has demonstrated the structural and functional vulnerability of the maturing brain to the damaging effects of alcohol and other drug abuse. Adolescent substance abuse has been found to limit brain growth (Volkow et al., 2008) and differentiation (De Bellis et al., 2005), with decreases in prefrontal cortex, grey matter, and hippocampal volume from alcohol abuse (De Bellis et al., 2005) and cannabis abuse (Nagel, et al., 2005). Also disrupted is the normal development of brain regions that mediate cognitive, conceptual, organizational and problem-solving skills, including the executive functions of attention, decision-making, planning, and conceptualization (Thorberg & Lyvers, 2006; Crean et al., 2011).

Normal development of reward-risk decision-making is impaired, resulting in decision-making deficits and impulsivity (Hanson et al. 2008). Adolescent alcohol abuse alters the mechanisms that regulate hypothalamic-pituitary-adrenal (HPA) axis activity, resulting in persistent dysregulation in HPA biorhythm and stress response, dysphoria, impairment in emotional engagement and feedback networks as well as judgment and resultant behavior, and potentially an increased risk of suicidal behavior (Sher, 2007).

The healthy functioning of motivational and attachment systems is undermined by substance use in adolescence. Motivational systems become organized around fear and avoidance of substance withdrawal, cravings, and distress avoidance, and a corresponding dominance occurs in reward systems over cortical regions in shaping behavior (Volkow et al., 2008). With respect to attachment, the drug of choice effectively replaces human relationships as the context of addressing vital personal needs essential for growth developmentally. Treatment models must address this derailment of attachment both by active interference with the attachment to substances and by providing alternative human responsiveness to individual emotional needs.

The negative impact of substance use on the maturing brain is compounded by early use onset. Heavy cannabis use during adolescence is associated with a significantly earlier age of onset (2.7+ years) of psychotic illness than in non-cannabis abusing adolescents (Gonzalez-Pinto et al., 2008; Large, 2011), and a 4-fold risk in the development of affective disorder characterized by dysphoria, anhedonia, and suicidal ideation (Bovasso, 2001). Moreover, the manifestations of the negative impact of substance use on the maturing brain varies across individuals, as the impact is influenced by multiple factors including genetic and environmental factors, opportunity for symptom expression, personality characteristics, and the presence of psychopathology (Hicks et al., 2011; van Beek et al., 2011; Brown et al., 2008; Schulenberg et al., 2001).

The need for a developmental neurobiology approach

In recent years, scientific advances have greatly improved the understanding and treatment of psychiatric and substance use disorders. These include: the converging influences of genetic, environmental, biological, and psychosocial factors on brain function, structure, and vulnerability; the extent that environmental and behavioral factors influence brain neuroplasticity well into adulthood; and that use of psychotropic drugs, psychotherapy and psychosocial services with greater specificity for neurodevelopmental impairments associated with substance dependence and/or psychopathology can improve patient outcome.

Although science has dramatically advanced our knowledge of

causation and treatment, studies have documented the extent of departure from evidence- and scientific-based practices in the treatment of these conditions (Watkins et al., 2001). A longitudinal study of 1,088 youths in residential or outpatient treatment for drug abuse showed that although 67% reported having severe mental health problems upon admission, only 24% received mental health services within 90 days of admission (Jaycox et al., 2003). Another example comes from a landmark study of individuals with alcohol dependence, who received care consistent with scientific knowledge only 10.5 percent of the time (McGlynn et al., 2003).

In addition, programs based on the asylum concept (go away and return cured) of rehabilitation treatment fall short for emerging adults, perhaps most likely due to the fact that such programs do not fully engage the emergent adult's experience-dependent brain systems. While such programs are often necessary and even life-saving for the initial phase of recovery, such programs do not take into account the distinct developmental needs and tasks facing emerging adults. Programs that expect young people to go away from their homes to receive treatment are likely to underestimate the need to engage the implicit, dissociated attachment and affect-regulatory systems, or self-structure and functions, at the deepest experiential level necessary to rebuild and re-network healthy living and loving patterns required for enduring recovery. The complexity of problems faced by emerging adults with substance use disorders coupled with the paucity of appropriate therapeutic options prompted the conceptualization of The Developmental Neurobiology Model.

Guiding principles

Neuroscience of emerging adult brain development guides the conceptual design of The Developmental Neurobiological Model of treatment for substance abuse in emerging adults. Three principles guide the treatment design. Each guiding principle ascribes therapeutic success to the provision of real-life opportunities for healthy attachment, emotional immersion, and neurosynaptic activation that are required for enduring change in self-organization, affect regulation and adaptive functioning.

The first guiding principle is that it is necessary to 'quiet the limbic system' (van der Kolk et al., 2005) to help emerging adults achieve a greater sense of safety. Quieting techniques facilitate attachments by promoting self-soothing and regulation. This is especially relevant when substance abuse is associated with trauma, anxiety disorders, and emotional/self-inhibition.

The second guiding principle is the belief that it is essential to support the psychoneurobiological development of a coherent self, an organized self, and a self-regulated self (Schore, 2008; Siegel, 1999; Gedo & Goldberg, 1973). This principle puts an emphasis on the processes of self-informed agency, self-directed empowerment, and an adaptive balance of vulnerability, collaboration, and boundaries for self-protection. This second pillar emphasizes the self-actualizing tendencies of the developing individual.

The third and last precept is drawn from *neurocognitive modes of decision-making* (Noel et al., 2006); therapeutic experiences thatoccur in real-time within meaningful relationships are essential for achieving change. Such experiences exercise and grow the networking between the limbic system and pre-frontal cortex. Using mindfulness techniques such as 'Reaction, Reflection, and Relation' neurocognitive growth occurs and, in turn, facilitates the development of mindfulness, cognitive and executive functions, and competent self-governance.

Intervention components

The Developmental Neurobiological Model for substance abuse treatment in emerging adults is an integrative model, one that uses the guiding principles to make adaptations to and adoptions from currently available treatment methods. Bringing together and molding multiple treatment methods into a method that works for emerging adults, honors the distinctiveness of the age period and the unique needs of this age group. Specifically, aspects of six well-established practices are components of the Developmental Neurobiological Model: abstinence goals, 12-step programs, psychiatric treatment, in-depth psychotherapy, executive function and role competence therapy, and mind-body integration work.

Abstinence

Abstinence from alcohol and/or drug use opens neural pathways necessary for the requisite emotional and cognitive processing in recovery, and resets the reward motivational system by improving self-efficacy – a factor highly correlated with successful treatment outcome. Abstinence is crucial in that it disrupts the primary attachment to one's drug of choice. Supportive medical and interpersonal treatment of withdrawal and cravings facilitates abstinence and resets the reward system. Intriguing evidence also suggests a period of abstinence following excessive alcohol exposure may result in a burst of growth of new nerve cells (Wobrock et al., 2009).

The 12-Step Recovery Model

Twelve-step theory hypothesizes that changes in specific cognitions (e.g., powerlessness over alcohol/drugs) and behaviors, including adoption of disease model beliefs and involvement in self-help programs, lead to symptom reduction (Morgenstern et al. 2003). Alcoholics Anonymous (AA) is a peer-based fellowship that provides mutual self-help and abstinence support through a network of informal community gatherings (Gunzerath et al. 2011).

The 12-Step model of recovery offers a structured platform to facilitate harm reduction and strengthen self-efficacy, empowerment, and governance in the connection to others. Limbic-cortical danger systems are mollified by reassurance and ever-present social safe places. Distressing emotions such as shame and loneliness are relieved through group membership; sponsors and members provide the organizing relationships to replace substance use at times of distress; self-worth, hope, and motivation are supported through acceptance; and the 12-step model confronts denial and rationalization while affirming the difficulties of sobriety.

Psychiatry

A considerable body of literature has documented the association between substance use disorders and a range of psychiatric conditions (Swendsen et al. 2010). Effective psychiatric treatment of psychopathology with psychotropic medication quiets the limbic system through reducing distress, supporting abstinence, reducing cravings and resetting brain reward systems. Patients who abuse multiple substances or have other co-occurring psychopathology are more likely to experience difficulties with treatment/medication adherence. Psychiatrists must also supervise the extended withdrawal from prescribed medications that may promote relapse, and help reframe substance abuse to the client as based on brain neurobiology, and thereby reducing self-criticism, shame, and a sense of failure.

Psychotherapy

A collaborative alliance between therapist and client has been established as the single best predictor of treatment outcome, especially in emerging adults. Therapeutic attachment experiences are transformed into internal regulatory abilities to create an adult socio-emotional framework better able to cope with the demands of life. Seen through the lens of developmental neurobiology, the therapeutic alliance must be attuned to issues related to safety and self-regulation, mirroring, validation, and visualization (Schore et al., 2008). Schore describes matching the clinician's right-brain attention to the patient's affective-arousal state, because immersion in the latter inhibits dissociation. This "limbic dialogue" utilizes self-disclosure and emphasizes the power of the present moment, within and outside of the therapeutic relationship. Therapy specifically targets the maturing brain systems and processes believed to mediate protective factors, such as emotional regulation and motivational systems essential to recovery from trauma, abuse and neglect thereby enhancing identity integration and coherence with resultant negative risk correlation (Schwartz, 2010).

Executive functioning and role competence therapy

Many of the cognitive and behavioral changes taking place during emerging adulthood can be understood from the perspective of increased executive functioning, a term encompassing a broad array of abilities that include attention, response inhibition, regulation of emotion, organization and long-range planning (Giedd, 2008). The use of fMRI imaging has helped link poor executive functioning with relapse, underscoring the importance in addressing executive functioning deficits (Paulus, 2005). Support for executive functioning is essential, not auxiliary, including within in-depth psychotherapy which opens the brain's neurobiology through attunement and provides optimal conditions for new cognitive learning. A useful strategy which addresses functional impairment and improves skills is Brief Action Planning (BAP). With BAP, the patient identifies an interest and the next step toward goal attainment to improve confidence and commitment. Action analysis is used in problem solving and strategic planning with an eye towards risk-reward recognition and consequences, resistance to negative peer influence and identification with the sober community. Motivational interviewing is also useful to assess and foster readiness for change, autonomy, and self-efficacy.

Mind-body integration work

For so many emerging adult substance abusers, especially those with trauma histories, the body is holding the unarticulated tensions of their emotional life. There is an urgency to relieve intolerable physical distress which is the engine of the "quick fix" of substance use. Approaches used to involve the body, connecting emotional pathways integrating the body-self include: techniques of distress tolerance through the use of dialectical behavioral therapy, exercise and yoga; meditation and mindfulness practices; heartmath and neurofeedback; practicing gratitude, compassion and forgiveness; and harm reduction through abstinence.

Resistance to recovery: stage-specific factors

Emerging adults present additional resistances to recovery based upon their developmental position. The emerging adult brain is reorganizing as it responds to exploration, novel experiences, and stimulation. Treatment and real life must compete with the experiences provided by substances in these domains. The maturational imperative for autonomy, self-empowerment and the associated illusion of invulnerability must be counterbalanced with an approach that defines self-directed strength as knowing one's limits and acknowledging risks, exposing vulnerability and the need for others, and accepting the legitimate expectations of authority.

Psychotherapy is to be directed at demonstrating how attachment to substances and dishonest, secretive interactions actually maintain powerlessness and dependence on unusable attachments. Dishonesty and secretiveness often provide illusory experiences of separateness, empowerment and autonomy in substance abusing emerging adults. Dishonesty and secrets stall individuation as, by definition, they keep hidden the authentic self. The role of shame and resulting avoidance and deception in substance abusing emerging adults cannot be overestimated, as many have been using substances during critical developmental years of adolescence and are truly impaired in many social, emotional and executive dimensions. Shame is muted over time by acceptance without judgment and offering alternative empathically derived understandings in individual settings, among family, and within peer and recovery communities.

The normative developmental narcissism of emerging adulthood presents challenges both in terms of acknowledging that one's life is connected to others and to a transcendent dimension of life. This challenge can be approached through involvement in the recovery community where the relational impact of substance use is ever present and an emphasis is placed on the paradox of self-empowerment and meaning through humility, gratitude and acceptance.

Conclusion

The Developmental Neurobiology Model offers an integrated treatment paradigm for treating emerging adults ages 18 to 29 with substance use disorders. This model is organized around the core principles of quieting the limbic system, promoting self-integration and coherence, and promoting executive function and competence. Interventions are targeted at providing a context which will interfere with the attachment to substances and promote human attachments allowing the individual and their brain to get back on track in maturation. Additional interventions promote development in those specific brain networks which affect self-integration, self-regulation and cognitive decision-making.

This treatment model is strongly grounded in and guided by the latest research findings of the sociocultural, genetic, and neurobiological factors that heighten substance abuse vulnerability, and the extent that substance abuse further compromises antecedent brain dysfunction and creates abnormal "rewiring" in neuron networks involved in motivation, reward, and executive function in the maturing brain. The Developmental Neurobiology Model informs a uniquely comprehensive approach to address the service of young people making the critical transition to adulthood.

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