Neurobiological Processes of Risk and Resilience in Adolescence: Implications for Policy and Prevention Science

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ABSTRACT—This article focuses on the concepts of risk and resilience and their potential to inform clinical interventions, school-based prevention programs, and social policies. Research suggests that childhood adversity can trigger a cascade of psychological and neurobiological events that can lead to mental disorders in later life. Yet little is known about how these processes manifest in adolescence, a developmental window that is typically associated with an elevated risk for psychopathology and represents a period of neurological growth and reorganization that is second only to early childhood. A better understanding of adolescent brain development may provide an empirical grounding to improve the focus and timing of interventions, particularly those that target self-regulation, meta-cognition, and social supports. Finally, opportunities and challenges that emerge when bridging neuroscience and prevention science are discussed.

A key question for psychologists, educators, and policy makers is to understand how young people thrive in the face of challenging life circumstances. What allows two individuals who are otherwise matched to take two vastly different developmental trajectories? How can society empower young people to succeed, in spite of a noxious upbringing? Epidemiologists present a sobering account of how turbulent the teenage years can be: as many as one in four adolescents experience an episode of depression or anxiety (Kessler, Avenevoli, & Ries Merikangas, 2001), 16% of British children are subject to a form of serious maltreatment by their caregivers (Cawson, 2002) and unprecedented numbers face chronic health problems, low self-esteem, and school failure (Dumont & Provost, 1999), not to mention surviving the regular vicissitudes of adolescent life. From the standpoint of education and public health, these challenges signal the need for a greater understanding of risk and resilience, with important ramifications for clinical and psycho-educational intervention.

OPERATIONALIZING RISK AND RESILIENCE

Since the advent of psychiatry, it has been well known that certain biological, psychological, and sociocultural stressors—commonly known as “risk factors”—test an individual’s capacity to develop in optimal ways (Rutter, 1985). These include, among many others, experiences of maltreatment (Belsky, 1993), poverty (Luthar, 1999), traumatic life events (Bonanno, 2004), and exposure to violence (Krug, Mercy, Dahlberg, & Zwi, 2002). However, beginning in the 1970s, evidence began to accumulate to show that history need not be destiny. Early investigators found that some children of schizophrenic parents flourished, despite the erratic nature of their upbringing (Garmezy, 1987). Similarly, a seminal longitudinal study conducted over 30 years showed that robust social support networks, scholastic competency, and the availability of positive role models seemed to buffer children from otherwise deleterious life events (Werner & Smith, 1992).
The term “resilience” is generally applied to these individuals who demonstrate positive adaptation in spite of risk-potentiating life experiences (Luthar, 2003; Rutter, 1985). Defining positive adaptation, however, has been the focus of much scholarly debate: some focus on meeting certain benchmarks for developmental or educational competence (Elder, 1998); others have focused on the absence of psychopathology, or a “bouncing back” after hardship (Collishaw et al., 2007); others still, more radically, aver that the traditional approach to resilience is too contingent upon Western cultural norms to warrant scientific investigation at all (Ungar, 2004). Equally contentious is what constitutes a risk, and by what standards. Risks can be defined as an exposure to a single cataclysmic life event (such as a natural disaster), enduring a prolonged and malign stressor (chronic illness or maltreatment), or experiencing a distressing but commonplace teenage experience (peer rejection or family conflict). What one designates as “resilience” is therefore predicated on the sociocultural context, the population at hand, the risk and protective factors involved, and our definition of positive adjustment. Researchers have also underscored that resilience is a dynamic process rather than a characteristic of the individual (Luthar, Cicchetti, & Becker, 2000). Accordingly, some scientists have argued that the term “resilient” is not appropriately applied as an adjective to describe a person (e.g., “a resilient child”) but rather to profiles or trajectories of adaptation (Luthar & Cicchetti, 2006).

A logical and important question that evolved from early resiliency research is one of mechanisms. How might contemporary scholars progress beyond the mere identification of risk and protective factors, through to an understanding of the processes that underlie their effects (Luthar & Cicchetti, 2000)? Harsh parental discipline, for example, may confer vulnerability to aggressive behavior when a child internalizes negative perceptions of self-worth, or learns that aggression is an appropriate means to resolve conflict. Social support, in contrast, may be a buffer against stress by strengthening adolescents’ sense of security or by providing practical assistance with money or childcare. As this article will explore, there has also been a concerted effort in neuroscience to identify brain structures and circuits that may mediate or moderate the relationship between adversity and maladjustment.

DEVELOPMENTAL NEUROSCIENCE AND THE ADOLESCENT BRAIN

Over the last 50 years, the synthesis of neuroscience, developmental neurobiology, and psychology has permitted researchers to surmount the disciplinary boundaries that once separated the social and the biological sciences. Within this framework, both typical and atypical developmental processes are necessarily studied at multiple levels of analysis, whereby the organism is simultaneously investigated through the lenses of society, mind, genes, and brain. Until recently, the study of the neural underpinnings of resilience in adolescence was hindered; first by a dependency on postmortem brains, and subsequently by harmful neuroimaging methods that were reliant on exposure to ionizing radiation (Giedd, 2004). Over the past two decades, however, the advent of new biotechnologies (particularly magnetic resonance imaging) has offered a sensitive, high-resolution methodology to study structural and functional aspects of brain development in vivo. These studies have underscored the importance of positive early experiences in fortifying brain architecture, and the deleterious impact of adversity on brain development, learning, and both physical and mental health (Shonkoff, 2010).

Another key finding was that the human brain, particularly frontal and prefrontal cortex, continues to develop well into the teenage years. Scientific and cultural narratives have historically characterized adolescence as full of psychological turmoil; a transitional period of “storm and stress” (Hall, 1904). Although anthropological evidence suggests this view to be partly culture-bound (Choudhury, 2010), research points to this period as a developmental window of rapid neurological and hormonal change. Neuroimaging studies demonstrate that the brain is in particular flux during adolescence, catalyzing newfound capacities for rational thought, emotional mastery, and self-reflection (Blakemore & Choudhury, 2006). Cerebral volume, peaking during early adolescence (at the age of 14.5 in boys and 11.5 in girls), begins to diminish, settling in its final, mature form in early adulthood (Giedd et al., 1999). Counterintuitively, increasing cognitive ability generally corresponds to a loss of redundant synaptic connections, a change that is thought to represent the suppression of competing, redundant neural pathways. Specifically, gray matter—the substrate of cognitive processing—matures nonlinearly along an inverted U-shaped trajectory, reflecting postpubescent synaptic pruning (Blakemore & Choudhury, 2006). This protracted process of synaptic downsizing allows the developing brain to become functionally and structurally reorganized by the environment to accommodate developmental needs: a phenomenon known as neuroplasticity.

A possible implication of this research is that, like early childhood, adolescence may represent a sensitive window in which to fortify the architecture of the developing brain. Similar to the way that young children lose the ability to distinguish speech sounds to which they are not exposed, adolescence may present an important opportunity to influence critical aspects of social cognition and executive functioning before they crystallize in the brain (Blakemore & Choudhury, 2006). On the one hand, this holds great promise for adolescent-targeted interventions that seek to strengthen motivation, reasoning, social competency, and
emotion regulation. On the other hand, this plasticity may render the developing brain sensitive to stress, compromising key neural circuits that support cognition, emotion and learning, and leaving them vulnerable to both common (personal and sexual identity formation, bullying, drug use) and highly pathogenic (trauma, abuse, exposure to home and community violence) life experiences. Understanding these mechanisms of change, both at the level of brain and behavior, is therefore an important task in advancing our understanding of resilience.

**PROTECTIVE AND RISK PROCESSES: EXAMPLES ACROSS MULTIPLE LEVELS OF ANALYSIS**

The following sections review recent evidence demonstrating adaptive and maladaptive processes for children and adolescents experiencing adversity across biological, psychological, and social levels-of-analysis. An exploration of these multi-level factors will be examined with respect to: (1) executive functioning and other higher-order cognitive skills necessary to self-regulate in the face of stress; (2) positive affectivity, or the ability to experience enduring and appropriate positive affect; and (3) social context factors, particularly attachment relationships, that can buffer individuals from the effects of adversity.

**Cognitive Skills: Executive Functioning and Self-Regulation**

The term “executive function” refers to a broad constellation of cognitive skills encompassing, but not limited to, attention, memory, goal-directed activity, and inhibitory control (Blakemore & Choudhury, 2006). These processes emerge early in childhood, and follow a protracted (but discontinuous) developmental trajectory from birth until adulthood, and whose maturation is likely determined by the fluctuations in synaptic growth and death in the brain. It is not until adolescence, however, that these skills—metacognitive, sophisticated, and adaptable—begin to resemble their adult form, coinciding with a developmental window that Piaget termed the “formal operational stage” (Fischer & Silvern, 1985). As Denckla (1996, p. 264) notes, “the difference between the child and the adult resides in the unfolding of executive functions,” suggesting that these skills are crucial in being able to meet desirable developmental, educational, and psychological outcomes. Conversely, deficits in executive functioning have been evidenced in those children with developmental disorders as diverse as ADHD, autism, and oppositional defiant disorder, to name but a few (Barkley, Edwards, Laneri, Fletcher, & Meteia, 2001; Clark, Prior, & Kinsella, 2002; Ozonoff, Pennington, & Rogers, 1991).

Cognitive skills, particularly problem solving, self-regulation, and cognitive flexibility, are implicated as important protective factors for youth growing up in conditions of adversity. Self-regulation, or the ability to flexibly and effortfully modulate internal states and experiences, is thought to be a core process when coping with stress and hardship (Gross, 2002) and predicts educational outcomes in both early childhood and adolescence (Blair, 2002). Studies of adolescents experiencing prolonged military conflict have also shown an association between cognitive capacity and psychological adjustment (Qouta, Punamäki, & Sarraj, 1995). It is therefore likely that regulatory abilities facilitate the sort of metacognitive, self-directed capabilities necessary for optimized learning, as well as inhibiting unwanted thoughts, feelings, and behaviors.

At least three sources of evidence point to the importance of self-regulation for the study of resilience. First, individuals experiencing adversity have been found to be at risk for a wide range of self-regulatory deficits. Maltreated children, for instance, have greater prevalence of depression, anxiety, inattentiveness, and aggression when compared to their peers (Shields, Cicchetti, & Ryan, 1994). They can also be emotionally sensitized to threat, allocating increased attentional resources to angry faces (McCrorry, De Brito, & Viding, 2011). A key feature of resilience may therefore be to avoid generalizing specific fear-conditioned responses to more mundane, everyday contexts. Second, typically developing children with higher rates of “effortful control” (a regulatory construct indexing attentional focusing, inhibition, and perceptual sensitivity) are less prone to negative affect such as anxiety, depression, and aggression (Muris, van der Pennen, Sigmund, & Mayer, 2008), possibly because it allows children to channel their attention toward positive and socially appropriate behaviors, rather than ruminate on negative thoughts and feelings. Finally, it appears that experiences of early adversity are associated with hypo-activation in areas of the cerebral cortex associated with the inhibitory control of emotion. For example, PET scans of postinstitutionalized orphans found decreased activation in the orbitofrontal cortex when compared with age-matched peers (Chugani et al., 2001), an area that has been associated with selective attention and emotional regulation (Quirk & Beer, 2006). It is possible that activity in these brain regions could modulate the relationship between adversity and dysfunctional regulation of emotional states.

Neuroimaging investigations have posited two main cortical networks likely to maintain, amplify, or attenuate responses to emotional stimuli, and therefore play a key role in coping with stress. The first, which I will refer to here as the “excitatory system,” encompasses the limbic structures of the amygdala, putatively associated with threat appraisal and fear conditioning (Davidson, Putnam, & Larson, 2000) and, to a lesser extent, experiencing positive emotions (Hamann, Ely, Hoffman, & Kilts, 2002). In adult patients with posttraumatic stress disorder, the amygdala is thought to be highly sensitized to threat cues, possibly suggesting that these individuals...
over-appraise environmental stimuli as aversive or injurious (Shin, Rauch, & Pitman, 2006), and structural imaging studies have also reported larger amygdala volumes in adolescents with a maltreatment history (Mehta et al., 2009, Tottenham & Sheridan, 2010).

The second region, which I refer to as the “inhibitory” system, is served by frontal and prefrontal brain networks and implicated in executive functions such as working memory, conflict detection, and reappraisal (Mansouri, Tanaka, & Buckley, 2009). These regions are thought to provide top-down modulation of psychophysiological, emotion-related activity (Knight, Richard Staines, Swick, & Chao, 1999). This inhibitory system may also dampen contextually inappropriate emotional responses, and thus underpin “response-focused” strategies of emotional regulation (Gross, 2002). As such, chronic dysfunction in this inhibitory system is a likely precipitator of mood disorders such as anxiety and depression. Conversely, the balance of inhibitory relative to excitatory activity may be an important predictor of coping and resilient adaptation in the brain. Empirical findings from functional imaging studies have also corroborated the distinction between excitatory and inhibitory brain circuits. In a typical suppression paradigm, volunteers are asked to “suppress” (i.e., volitionally inhibit) or “attend” to a range of emotional stimuli while neural activity is measured (Ohira et al., 2006). In normal adult samples, these investigations have shown diminished activity in the amygdala concurrent with increased activity in the dorsolateral prefrontal cortex, orbitofrontal cortex (Ochsner et al., 2005), and the anterior cingulate cortex (Phan et al., 2005). Similarly, patients with depression evidence increased limbic activity and decreased dorsolateral prefrontal cortex activity when compared to controls (Siegle, Thompson, Carter, Steinhauer, & Thase, 2007). Studies of the structural correlates of regulatory mechanisms, however, have been less forthcoming. Although prolonged stress has been associated with greater amygdala volume in rodents (Mitra, Jadhav, McEwen, Vyas, & Chattarji, 2005), this finding is mixed in humans, with some showing increased volume (Mehta et al., 2009) and others not (Woon & Hedges, 2008).

Taken together, these findings highlight the value of educational and clinical interventions designed to promote self-regulation and executive functioning in at-risk children and adolescents. Within an early childhood context, innovative programs such as Tools of the Mind have been shown to successfully improve school readiness and socioemotional competence (Barnett et al., 2008; Raver et al., 2011; Ursache, Blair, & Raver, 2012). Yet comparatively few programs have been developed to foster adolescents’ socioemotional resiliency. The neurobiological evidence surveyed here would suggest that the teenage years may be sensitive periods in which to foster higher-order cognitive skills relating to attention, meta-cognition, and socioemotional competence.

Positive Affectivity
Apart from its obvious intrinsic pleasure, sustained positive affect is thought to have great adaptive value in periods of stress or vulnerability (Ong, Bergeman, Bisconti, & Wallace, 2006). Happier and more optimistic individuals enjoy increased life expectancy (Danner, Snowdon, & Friesen, 2001), improved immune function (Pressman & Cohen, 2005), lower levels of the stress hormone cortisol (van Eck, Berkhof, Nicolson, & Sulon, 1996) and higher levels of self-efficacy and sociability (Lyubomirsky, King, & Diener, 2005). These findings favor the hypothesis that individual differences in positivity may modulate neurobiological responses to stress. On the cognitive level, experiencing positive affect aids problem solving, facilitates learning, and helps maintain equanimity in emotionally arousing situations. In Fredrickson’s (2001) broaden-and-build theory, positive emotions are argued to broaden the repertoire of thought and action, expanding the range of possible behaviors and promoting flexible cognitive strategies. Negative emotions, in contrast, are well known to narrow the scope of thought, instigating one of a small number of small behavioral and cognitive scripts centered around primal survival mechanisms such as the “flight or fight” response (Davitz, 1969). Fredrickson (2001) suggests that repeated exposure to positive emotion builds long-term psychological resources that can buffer against future adversity.

Personality factors, particularly those related to positive or negative emotions, may also covary with resilience (Friberg, Barlauw, Martinussen, Rosenvinge, & Hjemdal, 2005). Personality and psychophysiology are interrelated from an early age, with neonatal stress reactivity predicting temperament later in life (Gunnar, Porter, Wolf, Rigatuso, & Larson, 1995). In a study of post-Katrina youth, trait anxiety before the hurricane predicted later PTSD symptoms (Weems et al., 2009). In adults, those who are high in extraversion (self-rated as energized, optimistic, and sociable) report more daily positive emotion than introverts (self-rated as self-contained, solitary, and shy; Costa & McCrae, 1980). These findings are corroborated by functional imaging studies, which report that extroverts have increased neural activity in the emotion-processing loci of the brain, the amygdala, and the prefrontal cortex, when viewing positive photographs, whereas introverts showed attenuated responses in these areas (Canli, Sivers, Whitfield, Gotlib, & Gabrieli, 2002). Indeed, it has been suggested that “extroverts and neurotics are phenomenologically attuned to stimuli of positive and negative emotional significance, respectively” (Mobbs, Hagan, Azim, Menon, & Reiss, 2005, p. 16503). In summary, these findings are consistent with the hypothesis that certain personality types “up-regulate” positive emotion, whereas others fail to enhance these emotions using the same regions.

Presently, research on the promotion of positive emotions and optimism in school-aged children is at an early stage. However, one promising form of educational intervention for
use with adolescents is mindfulness training (Kabat-Zinn, 2003). Mindfulness is considered to be a state of heightened awareness characterized by being open, nonjudgmental, and receptive to one’s moment-to-moment experiences (Brown & Ryan, 2003). Accumulating evidence in both adult and child populations suggests that enduring states of mindfulness are associated with several dimensions of well-being, including optimism, self-regulation, experiences of positive emotion, and resilience (Schonert-Reichl & Lawlor, 2010). Moreover, participation in a mindfulness-based stress-reduction program as short as 8 weeks has been found to induce structural changes in the amygdala (Holzel et al., 2010). School-based mindfulness programs may be one opportunity to promote resilience by targeting socioemotional competency and other aspects of psychological well-being.

Social Context Mechanisms of Resilience and Vulnerability: Attachment Relationships
In both clinical and typically developing adolescent populations, social support is a well-established protective factor or “buffer” for psychopathology or maladjustment (Demaray & Maleck, 2002). Social support has been implicated in reducing stress levels (Whitman, Borkowski, Schellenbach, & Nath, 1987) and improving parental competency in teenage mothers (Thompson & Peebles-Wilkins, 1992); it is also positively related to self-esteem and academic adjustment in typically developing adolescents (Rueger, Malecki, & Demaray, 2008). It is therefore not surprising that building social networks of trust and support are objectives of nearly all prevention and intervention strategies working with at-risk youth.

Decades of research involving both human and nonhuman animals have documented the importance of healthy social relationships on psychological and neurobiological development (Davidson & McEwen, 2012). Attachment relationships with primary caregivers establish powerful internal working models for how a child forms future social connections (Bowlby, 1983). Children with parents who are emotionally available, responsive, and nurturing are typically more resilient in the face of threat, employ more constructive coping strategies, and are more socially competent in adulthood (Laible, 2007). Conversely, parent–child relationships that are characterized by disorder, conflict, or detachment can negatively impact the basic physiological and neural processes that support healthy development (Davidson & McEwen, 2012; Davidson et al., 2000). Converging evidence suggests that early psychosocial stress can alter the functioning of key physiological response systems such as the hypothalamic-pituitary-adrenal axis (McCrory et al., 2011), as well as the development of brain regions associated with the regulation of affect and homeostatic control, including limbic and paralimbic structures such as the orbitofrontal cortex, insula cortex, anterior cingulate cortex, the temporal poles, and the amygdala (Davidson et al., 2000; Schore, 2001).

Emerging evidence also suggests that genetic and epigenetic mechanisms may mediate the stress response, increasing the likelihood of resilience after adversity (see McCrory et al., 2011, for a review). Rodents exposed to a stressed-abusive “caregiver” incur lasting changes in the expression of the brain-derived neurotrophic factor (BDNF) gene in the prefrontal cortex (Roth, Lubin, Funk, & Sweatt, 2009), an area implicated in self-regulation. Interestingly, the same study reported the same altered gene expression in the progeny of the maltreated rodents. Such epigenetic transmission may be a possible mechanism of the intergenerational cycle of maltreatment reported in humans. Kaufman et al. (2004) investigated the onset of depression symptomatology in a group of maltreated children; they found that individuals with a short allele of the 5-HTTLPR gene conferred a vulnerability to depression only when social support was absent. Taken together, these findings suggest that positive social support networks, especially from primary caregivers, are likely to have a strong protective influence at psychological, neurocognitive, and biological levels of development.

Knowledge about the importance of healthy attachment relationships can be used to inform multifaceted intervention strategies working with families. One emerging insight is that programs designed to build parent capacity and resilience will yield positive outcomes not only for the adults themselves but also for the children in their care. Relevant examples are strategies used to ameliorate maternal depression, which affects a significant proportion of mothers living in poverty (Beardslee, Ayoub, Avery, Watts, & O’Carroll, 2010). Depressed mothers are typically less responsive to their children’s needs, have fewer positive interactions with them, and may provide a less stable home environment (Goodman et al., 2011). The presence of depression, particularly in urban communities, may consequently imperil the attachment relationships necessary to buffer children from the effects of poverty and other adversity. Encouragingly, adverse child outcomes associated with maternal depression can be partially remediated through family-based interventions (Garber, Ciesla, McAuley, Diamond, & Schloredt, 2011). Effective capacity building in adults that strengthens the quality of caregiver relationships is therefore one promising mechanism by which to indirectly foster resilience in children and adolescents.

**DISCUSSION: IMPLICATIONS FOR POLICY AND PREVENTION SCIENCE**

Decades of compelling research have provided evidence that early adversity potentiates poor outcomes across a range of domains, including socioemotional development, educational...
achievement, and physical and mental health. In addition, scholars have emphasized the importance of protective factors in fortifying key psychological and neurobiological systems that may reduce or eliminate adjustment problems, as well as fostering resilient adaptation for children and adolescents “at risk” (Luthar et al., 2000). Accordingly, the Scientific Council on the Developing Child (Center on the Developing Child at Harvard University, 2010, p. 13) a multidisciplinary coalition of scientists working on issues of child development and policy, conclude that “a science-based approach to the promotion of health and prevention of disease would be well served by strategic investments that build the capacities of communities and families to strengthen the foundations of healthy development in young children.”

The remarkable converging of neurobiological, psychological and educational data has already provided a powerful impetus for federal agencies to channel greater funding into the development of early childhood programs. One of the assumptions underlying these strategic investments is that prevention, particularly in the first 5 years, is much more cost-effective than remediating the symptoms of maladjustment after they have taken root. Supporting evidence from early intervention programs in disadvantaged communities (e.g., the Perry Preschool Program in Ypsilanti, Michigan) shows that growth-promoting experiences early in life can have a large impact on human capital formation, including school and college completion, home-ownership, criminal activity, and economic productivity (Heckman, Moon, Pinto, Savelyev, & Yavitz, 2010).

However, while these investments in the first 5 years of life are certainly laudable, we should not discount the importance of other leverage points throughout development. Well-resourced early childhood environments are necessary not because the window of influence closes at age 5, but because they set the foundations for later learning. Not only are the effects of early childhood programs maximized when they are followed up with supports later in development (Knudsen, Heckman, Cameron, & Shonkoff, 2006), but adolescents face many distinct challenges, many of which educators and clinicians seek to address. Moreover, interventions may be able to capitalize on adolescents’ newfound capacities for self-regulation and goal-directed behavior in order to promote positive psychological growth. An improved understanding of how to develop and refine adolescent-targeted interventions will be generated through complex multilevel models that explicate how neurobiology (particularly prefrontal cortex development), pubertal, and hormonal changes, interact with life experiences in the teenage years.

Translating Basic Science Research on Risk and Resilience: Challenges and Opportunities

It is now commonly held that scientific knowledge from genomics, neurobiology, and cognitive neuroscience can stimulate new ways of thinking about policy initiatives, disease prevention, the alleviation of poverty, and other inequalities, and the implementation and evaluation of interventions that aim to promote positive developmental outcomes (Shonkoff, 2010). Yet the partnership between scientists and policy makers does not come easily, and both parties need to create a discursive space in which to discuss both what needs to be translated (and how), and to probe the practical, political, and ethical challenges that arise when scientific research enters public discourse.

There are several reasons to be cautious about the utility of biotechnologies (MRI, genotyping, glucocorticoid assays) for policy and prevention science. First, the correspondence between biology and behavior is complex and often poorly understood, and can change across the life course. As an example, salivary cortisol levels are consistently associated with externalizing problems in preschoolers and elementary school-aged children, but not in adolescents (Alink et al., 2008). Additionally, the interpretation of brain structure–function relationships is likely to vary across adolescence and adulthood. In adult populations, greater regional gray matter is often found to reflect a functional advantage, whereas the same differences in adolescence could represent a maturational “lag” in synaptic pruning. Until the biology-behavior link is more clearly understood, the ability to interpret this research will remain limited.

A further source of challenge comes from the considerable financial cost associated with brain imaging, genotyping, and other technologies. Currently, the kind of mental health care that is provided in the United States and many other developed nations does not adequately meet the needs of children and adolescents, particularly those in poverty (Mulye et al., 2009). Consequently, Luthar and Brown (2007, p. 6) persuasively argue that “for the thousands of at-risk children and families lacking any kind of health insurance, it would seem that there is limited hope, in the foreseeable future, that these expensive technologies will be harnessed for individualized tailoring of mental health treatments according to their unique psychobiological profiles.” Balancing cost-effective, evidence-based interventions with greater financial investment in mental health services is crucial if this is to change.

Finally, it is inevitable that knowledge from brain scans and other biotechnologies will raise unprecedented ethical dilemmas for researchers, policy makers, practitioners, and families (Illes & Bird, 2006). How might neuroimaging guide decisions about treatment, and to whom? How might labeling (or even mislabeling) children affect their treatment in schools, homes, and hospitals? How might brain imaging alter our perception of what constitutes “typical” and “atypical” development? Robust ethical guidelines are critical in protecting those children and families who have both the most to gain and the most to lose.
Nevertheless, scientific knowledge from the biological sciences also offers considerable promise. Although a fully elaborated description of possible implications is beyond the scope of this article, here I sketch a few possible applications. To begin with, the neurosciences add converging biological evidence to support existing epidemiological, behavioral, and psychological accounts of risk and resilience. Scientific narratives—what Shonkoff and Bales (2011) call a “core story”—represent powerful rhetorical devices that capture the attention of the public and policy makers. Biological data may be seen as particularly persuasive because they are perceived as offering more precision and clarity than data from other sources.

Second, evidence suggests that neurobiological or epigenetic information may be used to assess and differentiate treatment responses to clinical or educational interventions. Currently, interventions with child and adolescent populations typically use self, teacher, parent, or clinician reports to assess the effectiveness of a given program. However, the addition of “objective” neurophysiological data to self, parent, teacher, and clinicians reports may yield a more accurate and reliable image of treatment efficacy by complementing data at the level of behavior to also include more subtle neurobiological information. Biological data may be particularly valuable, for instance, because biological changes may precede changes at the behavioral level, or in cases where neurobiological systems may be more sensitive than behavioral assessments (Cicchetti & Gunnar, 2008; Gabrieli, 2009).

Finally, there is the interesting prospect that cognitive, neurological, and genetic markers may aid in the early identification of psychopathology, or in guiding appropriate treatments or interventions for child and adolescent populations with particular risk profiles. Recent research in genetics and psychiatric epidemiology has sought to identify biomarkers or endophenotypes that mediate the path between genes (and other causal agents) and developmental or health outcomes in childhood and beyond. One relevant example is the exploration of psychobiological precursors to suicidal behaviors. Suicide is considered a serious public health risk, representing the 11th leading cause of death in the United States, and increases almost fivefold during adolescence and represents the 11th leading cause of death in the United States, and increases almost fivefold during adolescence and early adulthood (Nock et al., 2008). Studies suggest that certain psychobiological abnormalities are associated with liability to suicidal behaviors, often independent of comorbid psychiatric disorders (Court et al., 2011). Neuroimaging studies have revealed that patients with a history of suicidal behaviors show differential brain activity in the orbitofrontal cortex when viewing angry faces, possibly because angry faces signal social disapproval or rejection (Jollant et al., 2008). Additionally, suicidal behaviors are associated with impulsive or aggressive personality traits, altered skin conductivity, and biological abnormalities in the serotonin transporter promoter variant 5HTTLPR (Court et al., 2011). These findings have heuristic importance because they may help scientists to develop more accurate and reliable prediction models before the onset of clinical symptoms, and may therefore hold particular value for prevention and intervention programs.

CONCLUSIONS

Adolescence is uniquely positioned as a time of psychosocial, interpersonal, and neurobiological change. These changes present both opportunity and challenge: on one hand, affording new possibilities for growth, self-reflection, goal-directed behavior, and mastery; on the other, conferring vulnerability to undesirable psychological and educational outcomes. Elucidating the mechanisms that underlie risk and resilience will require the bridging of multiple fields, including genetics, neurobiology, psychology, and education. Moreover, policy and prevention science are well poised to harness these findings and bring them to bear on interventions for adolescents. A continued understanding of the role of the brain in developing resilience is therefore likely to remain vital for parents, educators, and clinicians looking to promote positive psychological development in the teenage years.

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