

The science of the adolescent brain and its cultural implications

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1. Introduction

Scientific developments during the past two decades have ushered in new and widespread interest in the neuroscience of adolescent development, and what has come to be known popularly as the “teen brain.” Clinicians, policy makers, educators, parents and youth are increasingly informed by emerging scientific insights into the adolescent brain’s malleability and its sensitivity to environmental input from puberty through early adulthood. These findings have been made possible by the relatively recent availability of non-invasive neuroimaging techniques that have allowed researchers to attempt to identify the “neural underpinnings” of behavioral differences between adolescents, adults and children (Choudhury, 2010). The rapid growth of a research domain dedicated to adolescent brain development has challenged the older assumption of brain rigidity after late childhood in developmental science (Fuhrmann et al., 2015) and has given rise to an increasingly neuroscientifically-informed and brain-centered understanding of adolescence in wider culture. As such, there has been widespread appeal for applying the view of the adolescent brain as a *different brain* – from the adult and child brain – to several societal domains of everyday life of youth. In this chapter, we describe the development of this emerging science, the implications for policy and public engagement, and the controversies therein. Finally, we discuss the importance of understanding this new science in its cultural contexts.

1.1. State of the science on adolescent brain development

The recent neuroimaging (MRI (Magnetic Resonance Imaging) and fMRI (functional MRI)) studies support earlier, smaller scale postmortem studies in the 1970s in suggesting that ‘sensitive periods’ of development of the human brain may be more protracted than previously thought (Huttenlocher, 1979). The adolescent brain is now frequently described as “a work in progress” to emphasize the structural remodeling and neuronal reconfiguring that occurs as the child brain transitions to the mature adult structure. This growing body of research has shown functional and structural changes in the brain during adolescence hypothesized to correspond with behavioral changes during this period (Nelson et al., 2016). The two major changes identified during adolescence are linear increases of white matter volume which is implicated in more rapid transmission and processing of neural information, and non-linear decreases of grey matter volume, which is hypothesized to represent synaptic pruning -- the process of eliminating and “rewiring” synapses to maximize the efficiency of neuronal communication (Vijayakumar et al., 2016).

Data depicting white and grey matter development have generally been interpreted as processes of experience-dependent synaptic reorganization and increased myelination of nerve projections in several parts of the brain. The synaptic reorganization that takes place in adolescence is a function of the highly plastic nature of the adolescent cortex. Cortical plasticity refers to the brain's ability to reorganize and adjust its neural connections in response to environmental stimuli. “Experience-dependent” plasticity reflects the brain’s reaction to life-experiences, lays the foundation for human brain function, is responsible for all learning, and persists at a baseline level throughout life. In contrast, “experience-expectant” plasticity gives rise to distinct “sensitive periods” during the life span in which specific experiences must occur

for typical development (Fuhrmann et al., 2015). Human studies of sensitive periods have largely focused on early childhood (Kuhl, 2010) demonstrating highly plastic periods of language development and sensitive periods that underlie sensory capacities like sound categorization (Blakemore & Choudhury, 2006). Researchers have begun to hypothesize that adolescence is a second period of intense neuronal plasticity, characterized by experience-expectant periods, specifically sensitive to experiential input affecting executive functions and social cognition (Blakemore & Mills, 2014).

Empirical research has demonstrated extensive structural and functional changes in the brain during adolescence, particularly in regards to the frontal, parietal and temporal regions of the brain, but there has been much debate over the interpretation and findings of these studies (Tamnes et al., 2013). Discrepancies, in part, arise from difficulties characteristic to the logic of neuroimaging methodology. Functional imaging studies provide correlational information but cannot provide causal certainty, leaving the links between neuroanatomical development and changes in behavior and brain function unclear (Weber & Thompson-Schill, 2010). In addition, variability of age-range and pubertal status used to denote periods of “adolescence” “childhood” and “adulthood” leading to differing sample characteristics (Pfeifer & Allen, 2016), difficulties in extrapolating across different neuroimaging paradigms, techniques and loci of study in the brain across studies are just some reasons why researchers in the field hold disparate views (Richards et al., 2013).

1.2. The adolescent brain beyond the lab

However, these nuances and limitations remain under-debated while the appetite for the science in the public sphere and policy context has become increasingly strong. The appeal is clear: this research offers state-of-the-art scientific investigations into the brain basis of

behaviors that are often anecdotally or stereotypically associated with teenagers, particularly in Western societies, and offers potential avenues for intervention. For example, neuroimaging studies explain why adolescents make “poorer” decisions than adults (Galvan et al., 2007), and reveal the neural correlates of “high-risk behaviors” associated with adolescence such as increased sensation-seeking behavior and heightened impulsivity (Brown et al., 2015).

Stereotypical teen behaviors are thus explained, and validated, by experimentally detected changes in the brain. The prefrontal cortex (PFC) undergoes the most dramatic changes during adolescence. This is particularly significant, especially to researchers seeking to apply brain science to evidence-based policy-making and to inform young people about their brain health and personal identity, because this brain area is implicated in high-level cognitive capacities. The PFC is associated with capacities for behavioral control like decision-making, working memory and multi-tasking, emotional regulation and social cognitive skills such as empathy, perspective-taking, self-awareness and emotional recognition -- the very capacities at stake in the debates about the relevance of the developing brain for education, law, psychiatry and child-rearing.

These developing abilities are characteristic of this ongoing developmental phase frequently referred to as a period of “vulnerabilities and opportunities” (Dahl, 2004); adolescent neuroplasticity is thought to be both a source of risk (for onset of mental illness as well as problem behaviours in the healthy population) and at the same time a resource that can be tapped to harness the brain’s potential through various behavioural interventions. Such findings are thus increasingly sought by policy makers at a moment in which neuroscientific discourse is continually becoming more influential to the health and everyday lives of teenagers. Despite the widespread uptake and influence on policy and popular discourse, there are several important

methodological limitations, epistemological dilemmas and ethical questions surrounding the translation of new brain data into areas of society involved in the health and management of adolescent behaviours.

For example, the drive to produce applications of neuroscience and the trend towards evidence-based education sparked the field of ‘neuroeducation.’ This research agenda aims to build educational strategies that improve academic achievement and social development of young people, reframing curricula to reflect current research on the developing brain. These strategies are presented as science-based and implicate ambitious assumptions of what programs that aim to capitalize on brain plasticity can accomplish. Despite the preliminary nature of research data, findings from neuroeducation have begun to trickle directly into schools in the form of new customized teaching methods built around interpretations of data about social cognitive development and neurocognitive plasticity (Ansari et al., 2012). These methods aim predominantly to improve children and adolescents’ regulations of actions, impulses and emotions, and to provide a biological foundation for working with developmental disorders like dyslexia in the classroom (Howard-Jones, 2009).

This swift translation is not without controversy. Earlier attempts to bridge brain science and education through high-profile commercial projects such as Baby Einstein, Baby Mozart, and educational programs premised on left brain/right brain lateralization have been widely discredited (Maxwell & Racine, 2012), raising the need for greater scrutiny in the transfer of research to policy and educational practice. A primary critique of the commercialization and oversimplification of neuroscience is the emergence of “neuromyths,” a term that gained prevalence with the “Brain and Learning” report by the OECD in 2002, defined as “a misconception generated by a misunderstanding, a misreading, or a misquoting of facts

scientifically established (by brain research) to make a case for use of brain research in education and other contexts” (OECD, 2002). While researchers caution policy makers about the “seductive allure” (Weisberg et al., 2008) of “neuromythology” (Rose, 2005) and the risks of applying preliminary findings too soon, critical reflection on the brain data and interpretations outside the lab remain understudied.

Similarly, hopes for the role of this new brain science of adolescence in mental health have been set high, particularly in recent years since the recent reorientation of the National Institute of Mental Health (NIMH) research towards biological taxonomies (Insel & Lieberman, 2013). The goal of many researchers is to apply the logic of neurobiological markers of mental disorders into the context of adolescent psychiatry (Croarkin & Ameis, 2016). Imaging data on adolescent brain development and the potential for biomarkers in the clinic has been highlighted in the context of Attention Deficit/Hyperactivity Disorder (ADHD) -- a common disorder in school-age children characterized by inattention, impulsivity and hyperactivity (Sun 2012). Despite enthusiasm to import these methods among some in the clinical community, it is important to assess whether neuroimaging in its current state can play an appropriate role. How reliable are these as biomarkers in the clinical context? Can neuroimaging be used to diagnose ADHD? What might be some of the commercial, societal and cultural drivers behind the investment in neuroimaging as a purportedly more objective tool for psychiatric diagnosis?

Bioethicists and social scientists speculate that a rapid translation into clinical settings could occur through the creation of algorithms that combine neurobiomarkers with heredity, environmental and social risk factors to predict the probability that a single individual has or could develop the illness (Singh, 2008). These advances would mark the foundation of a re-engineering of the health care system that would assure novel streams of care especially designed

for adolescents, a period when mental illnesses are considered to be increasing in incidence (McGorry et al., 2011). Researchers in neuroscience, psychiatry and health policy – as well as clinicians and policy makers – have significant roles in shaping research programs directed towards the discovery and use of brain-based biomarkers in adolescence.

Critical neuroscience offers a reflexive and interdisciplinary framework to examine political, cultural and social contexts of neuroscience, while considering ways to integrate these contexts into the experimental study of the adolescent brain (Choudhury & Slaby, 2012). On the one hand, critical neuroscience draws on the notion of styles of reasoning to explore how knowledge, models and beliefs about adolescent behaviours are produced and communicated within the neuroscience community. Styles of reasoning refer to the ideas, practices, technologies and tacit knowledge drawn on when making a judgement (Young, 2000). On the other hand, critical neuroscience seeks to bring into view multiple methodologies and approaches to study the human mind, without privileging the biological level of inquiry. In this way, it aspires to enrich experimental paradigms and broaden the interpretive possibilities about behaviours and possible routes to intervention.

1.3 The “teen brain” as a unique brain in popular culture

The interpretation of brain data showing that the “teen brain” is different has gained increasing visibility outside the neuroscience community in the media, resonating strongly with current cultural conceptions of teenagers in Western societies. The popular model of the “teen brain” offers a new scientific explanation of developmental challenges while simultaneously providing a new vocabulary and set of metaphors to frame and interpret developmental challenges arising from normal development and illness. This is largely a result of the growing impetus for public engagement, or knowledge translation, activities that promote “neurotalk.” In

health promotion literatures including government websites, pamphlets and awareness videos, adolescence is understood as a paradoxical period of brain development during which teens undergo a phase of inevitable and normal “pathological” behavior which results from their ‘disorganized’, ‘underdeveloped’ or ‘maturing’ cortex simultaneous with increased risk for the onset of mental illness (Dahl, 2004). In other words, the typically developing brain is seen as “at risk”.

Since the 1990s, neuroscientific explanations about the “teen brain” have been central in newspaper, magazine and television reports claiming to solve the “secret” or “mystery” of risky, sullen, and rebellious teenage behavior in Canada, the USA and UK. Brain scanning studies provided salient explanations, for instance, about risk-taking, emotional immaturity and “suboptimal decisions” (Casey et al., 2008). Scientific arguments about the adolescent brain continue to penetrate the public domain, in the form of public lectures, popular science books and television programs. These popularized neurological explanations for stereotypical adolescent behavior tend to result in explanations -- often directed to parents and educators -- that “blame the brain” (Morgan, 2005).

Dissemination of public health information regarding the teen brain has shifted from exclusively targeting caregivers to engaging teens themselves as well (Choudhury et al., 2012). Public engagements have included interactive exhibitions, books, multimedia projects, and television programs. In the popular book *Blame My Brain*, Morgan (2005) explains different facets of teen life, like sleep and drug use, in terms of the immaturity of the developing teenage brain. PBS’s video series “Inside the Teenage Brain,” advertises “finding new explanations for why adolescents behave the way they do” (<http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain>).

Although well intentioned, empirical research with UK-based students aged 13-14 years old (Choudhury et al., 2012) demonstrates how neurocentric public engagement has potential to strip away teenagers' subjective experiences, while simultaneously creating new spaces to exact social control. The New Yorker article, *The Terrible Teens* (2015), quotes Frances Jensen, researcher and author of *The Teenage Brain: A Neuroscientist's Survival Guide to Raising Adolescents and Young Adults*, advising parents: "You need to be your teens' frontal lobes until their brains are fully wired." According to young people, being defined by neuroscience and this style of rhetoric inspired by neuroscientific discourse creates new ways of stigmatizing adolescents that reifies their lower societal status and essentializes long-standing societal tropes about teenagers (Choudhury et al., 2012). There has been limited investigation into the effects of public engagement and knowledge translation initiatives on the "teen brain" among various audiences. Further, research should investigate the possible implications to young people's own self-understanding that result from these initiatives which widely circulate brain-centered views of adolescence and regard adolescents' brains as "different", "in construction", "incomplete" and associated with notions of poor decision making, emotional volatility, impulsivity and risk-taking.

1.4 Situating the adolescent brain: historical, social and cultural contexts

In this section, we aim to emphasize that new insights about the central role of brain development, particularly since the "neuroscientific turn" (Littlefield, 2012), require an understanding of the brain as a cultural organ (Kirmayer, 2006). In other words, the human brain is the organ of culture which allows us to adapt to varied and demanding social contexts and environments. This emphasis on social and cultural contexts of the developing brain is crucial to understanding a period of development during the lifespan that is as much defined and shaped by

social and cultural transitions as it is by biological maturation. When reviewing this active and rapidly expanding body of brain research and applications for adolescents, then, researchers must acknowledge that the characteristics and experience of adolescence are variable and dependent upon the social and cultural environment to a degree that cannot be ignored. While the understanding of the brain as bathed in its environment at multiple levels is increasingly assumed by neuroscientists, recent research (Casey et al., 2016) clearly demonstrates that the integral role of the social context is lost in dissemination drives, ignored by policy-makers and at times insidiously shielded (Fine, 2010).

Models described in the growing body of neuroscience research that acknowledge the importance of social context and environment can be taken further by engaging with socio-environmental factors at a more elemental level. Paradigms that subordinate environmental effects to the course of neurological processes should be replaced by models that consider environmental effects as significant and fundamental as biological mechanisms. The intrinsic role of environment in brain development can be demonstrated by advances in epigenetics, which have been especially influential in fueling major shifts in scientific thinking about the relationship between the body and its environment (Szyf, 2013). Research on epigenetics has begun to reveal how interactions between the genome and the environment throughout development lead to tissue-specific structural changes in, for example, the DNA methylation patterns that regulate cellular function. There is compelling evidence, for example, that early parenting experiences and social adversity alter the regulation of stress response systems for the life of the organism (McGowan et al., 2013). Such studies provide biological evidence that lived experience, developmental histories, dynamic interactions, and cultural contexts are all fundamentally bound up with biological processes as “low level” as gene expression. Through

the case of adolescence, we explore the importance of a more integrative approach that considers brain, body and world, in which no process is uni-casual or firmly nested in another, but all equally mold and modify each other and themselves to a significant degree.

The historical construction of adolescence

Explanations that situate brain and cognitive function within the social and cultural environment of the person are increasingly called for from within neuroscience and psychiatry to develop multilevel theories of disease and their etiologies (Kendler, 2008). We add that to situate the brain in its social context, the historical contingencies of categories naturalized by neuroscience must be acknowledged. The category of “adolescence” has a well-documented history. Contrary to the way in which brain science of adolescent development is often interpreted, adolescence is not simply a naturally occurring period of development, or a consequence of brain changes or hormonal transitions. Indeed, it has long been argued by scholars in the humanities that adolescence is a cultural construction (Lesko, 1996). There is an extensive sociological literature documenting the social, cultural and economic factors -- such as changes in American family life, urbanization, employment changes and the introduction of full-time schooling -- that are understood to have shaped the lived experience of adolescence in Western Europe and the USA, and the way in which this period of the lifespan was categorized (Lesko, 1996). Concepts of adolescence in popular culture and theories of adolescent behavior in modern science have been characterized by notions of turmoil and a sense of a troubled transition, and likely have their origins in early 20th Century psychological science. Most notably, psychologist G. Stanley Hall popularized the concept of adolescence, putting forth influential theories of adolescence as an inevitable period of “storm and stress.”

Researchers have demonstrated that the scientific model of adolescence was imbued with the cultural values of a certain historical moment at the turn of the twentieth century. Hall's characterization of adolescence was guided by his evolutionary approach based on Ernst Haeckel's theory of recapitulation, which links stages of individual development to those of species evolution (Choudhury, 2010). A popular theory in scientific and sociological discourses at the time, this view assumed that intellectual and moral evolution of individuals and cultures reflect each other, and adolescence as a developmental stage represented the transition from primitive to civilized. Researchers have therefore argued that the category of adolescence was a vehicle through which those in power could address their fears surrounding "savages" and the emasculating and de-civilizing influence of 'others,' including women and colonized peoples (Lesko, 1996). In other words, the shaping of 'adolescence' as an age category during the early twentieth century was deeply contingent on the cultural and socio-economic concerns of the time.

Hall's 1904 book, *Adolescence*, explained that adolescents are driven to be emotionally labile, prone to delinquency, seeking intense sensations, liable to experiment with sex and alcohol, peer-oriented, and in constant conflict with parents. These ideas continue to be reproduced in contemporary Western discourse, shaping every stage of scientific practice -- from influencing the questions researchers ask to the ways in which researchers interpret results. Neuroscience interprets adolescent behaviors through the 'storm and stress' framework and as natural consequences of adolescents' asynchronous brain, cognitive and hormonal development. For example, across the literature concerning risk-taking in adolescence, researchers are often biased to interpret certain behaviors as "risky" rather than considering alternative explanations,

like those that posit higher reward-seeking behaviors as more reflective of social rewards and social learning.

Adolescence as a cultural phenomenon

Following the work of Margaret Mead (1928), many anthropologists and psychologists have investigated cultural variances in adolescence, challenging the universal conclusions advanced under neuroscience. Mead, when studying the relatively smooth and problem-free coming-of-age period in Samoa, first argued that “storm and stress” is just a function of certain cultural determinants and does not translate across all cultures. Although neuroscience demonstrates a specific set of neural changes during adolescence, this period is defined by social transitions, beginning with puberty and ending with a stable adult role (Schlegel & Barry, 1991). The expression, onset and duration of this period is embedded in cultural definitions of childhood and adulthood, and is dependent on the individual ecology of the young person. For example, studies suggest that psychological turmoil only occurs in cultures where there is an extended gap between childhood and adulthood (Saraswathi, 2002). Additionally, ethnographic work has linked longer periods of adolescence to societies whose training for adult roles is more complex (Schlegel & Barry, 1991). Further, certain characteristics of adolescence proposed as universal - like youth propensity for risk-taking and its subsequent decline with age - may actually be particular, and subject to the affordances of local environments. A recent paper found that harsher living environments were associated with raised liability for risk-taking and reduced differences for risk-taking between genders and between younger and older individuals (Mata et al., 2016).

The interface of history, culture and neuroscience

Despite its historical and cultural shaping, it is generally accepted that adolescence

defined as “any social stage intervening between childhood and adulthood in the passage through life” exists as a transitional stage worldwide (Dasen, 2000, p.25). Anthropologists Schlegel and Barry (1991) have published robust ethnographic evidence of this in an extensive work surveying 175 traditional (pre-industrial) societies, indicating a ubiquitous socially marked stage of adolescence. What then is the relevance of the historical and cultural context of adolescence to the neuroscience, which demonstrates that a unique stage of brain development occurs during adolescence? Neuroscience’s engagement with the adolescent brain assumes universality of findings, and interpretations of results tend to be consistent with this assumption, given that the brain is often believed to confer universality. However, cognitive neuroscience paradigms (including questionnaires and tasks completed in the imaging scanner) are created under the architecture of Western understanding and have largely been administered to, and standardized on, specific groups of participants deemed to represent the “norm”. This norm or standard, though, has recently been demonstrated to represent “White, Educated, Industrialized, Rich and Democratic” (“WEIRD”) societies (Heinrich et al., 2010), even though these groups are frequently unusual and not representative of large scale human populations.

Similarly, conclusions drawn about adolescence in mainstream developmental psychology and cognitive neuroscience have been extrapolated from very specific samples of teenagers, resulting in the classical “storm and stress” model applicable to certain Euro-American adolescents (Dasen, 2000). To illustrate, as of 2015 there exists only one study comparing brain development between Asian and North American youth. The dangers of extrapolating findings across diverse populations is evident from the study’s results which reported differences in morphological brain development between the two populations, which could implicate functional differences (Xie et al., 2015).

To integrate findings from neuroscience, psychology and anthropology, and situate the adolescent brain in its environment, it is also important to unearth the relevant meaning of various developmental goals processes associated with adolescence across cultures. For example, in investigating self-processing, a key interest of cognitive neuroscientists, researchers must consider a culture's definition and experience of self-construal that influences the individual's own understanding and experience of "self" (Ma & Han, 2010). The investigation of meaning will help us understand varying first-person experiences of adolescence -- for example, how individualistic and collectivist cultures differently experience and value the achievement of "autonomy" (Oyserman et al., 2002). Several contemporary psychological theories and practices regarding the development and treatment of psychiatric disorders are founded on the assumption of autonomy achievement. For example, researchers have identified individuation and autonomy as critical components in understanding the development of substance use disorders in teenagers. It is important to explore the role and centrality of autonomy achievement across cultures to understand the relevance of recommended interventions to clinical practitioners that result from such theories.

To make relevant and appropriate conclusions from neuroscientific findings, biological processes in the adolescent brain and body must be explored in relation to the context of the adolescent lifeworld, rather than in isolation. Furthermore, since neuroscientific inquiry has had enormous appeal beyond the laboratory in recent years, and is arguably giving rise to new forms of identity construction and ways of being, it is crucial to critically examine the development of neuroscientific models of categories of people (Hacking, 1995). Critical reflection is imperative during the impressionable, plastic period of adolescence, where individuals undergo profound

developments in self-concept and consciously or not, take up and embody popular conceptions linked to the ‘adolescent brain’ (Choudhury, McKinney & Merten, 2012).

Sociocultural and biological forces are inextricably entwined and mutually shape brain development and activity. Many studies demonstrate differences in neural activity across cultures and cultural effects on low-level attentional and perceptual neural processes, like those involved in object recognition, as well as on neural processes involved in high-level cognitive, emotional and social capacities like language, mental attribution and self-awareness (Duque et al. 2009). The fundamental influence of context is also highlighted by epidemiological studies, such as the wide body of literature documenting adverse health consequences associated with current and early-life urban living, whereby certain health risks – such as for schizophrenia, which develops in adolescence – increase linearly with the degree of ‘urbanicity’ (Ferranti et al., 2017). The environmental and socio-cultural constituents of the urban environment manifest in the brain, illustrated by fMRI studies that demonstrate unique neural social stress processing in individuals who currently reside, or were raised, in cities (Lederbogen et al., 2011). Reductionist accounts of the brain obscure the wider entanglements of biology, environment, culture and history. A critical interdisciplinary approach, however, can situate adolescent behavior and cognition in its ecological niche, and acknowledge the multiple levels at which developmental change is occurring.

Conclusion

The appeal of the neurobiology of adolescent development for translational applications is increasingly evident in areas of education, psychiatry and, though controversial, has been influential at the level of the US Supreme Court in the law (Steinberg, 2013). Applications of developmental cognitive neuroscience in society are premised on the finding from non-invasive

neuroimaging techniques that middle childhood to late adolescence represents a “sensitive period” of malleability -- or neuroplasticity -- during which environmental input can have particularly profound effects on development (Ansari et al., 2012).

Despite some neuroscientists’ warnings about the swift application of novel brain data to social applications, adolescent brain research is characteristic of a growing relationship between brain science and policy. Brain-based models of adolescence hold enormous appeal to multiple audiences, offering a biological explanation for challenging behaviors, mental disorders and stereotypical propensities. Parents, teachers and psychiatrists may find in these models a physical substrate that provides the hope for opportunities for educative, spiritual and medical remediation, and pre-emptive intervention. Moreover, brain-based models of adolescence provide a substrate that confers a ‘de-responsibilizing’ effect -- directing attention to the body of the adolescent rather than the familial, social, cultural or economic context in which she lives (Choudhury & Moses, 2016).

The power of the brain based model of adolescence to stigmatize young people as incomplete, immature or in turmoil, along with researchers’ evidence of the dangerously “seductive allure” of neuroscientific explanations (Skolnik-Weisberg et al., 2008) gives reason to turn to approaches that situate the developing brain in its ecological context. Recent trends in cognitive neuroscience suggest that the timing is right to integrate multiple levels of inquiry into investigations and explanations of adolescent behaviors. For example, social neuroscience demonstrates that the human brain is a fundamentally social brain, adapted for social learning, interaction, and the transmission of culture (Frith & Frith, 2010). Moreover, the brain’s structural malleability is understood to be experience-dependent and long-lasting, opening avenues for incorporating the study of interaction of brain, cognition and environment. A critically oriented

cultural neuroscience that is devoted to investigating the brain in the cultural context may represent a corrective to universalizing trends in neuroscience. Whereas mainstream neuroscience often assumes the universality of its findings, cultural neuroscience highlights the idea that cultural and social environments may be a source of variability in the functional architecture and activity of the brain. Some areas of cultural neuroscience draw on the tools of neuroscience in combination with methods in anthropology, to conduct research that takes seriously the notion that human brains are highly responsive to cultural input (Seligman & Brown, 2010). Because they allow collection of real-time data on neural function, as well as ethnographic methods, such techniques represent powerful tools for understanding how brains become encultured (Downey, Lende, & Brains, 2012).

The techniques of neuroscience currently have immense rhetorical potency within both scientific and popular contexts. To avoid the pitfalls of neuromythology, a situated view of the adolescent brain studied within a critical neuroscience framework can actively work against pervasive forms of biological reductionism (Kirmayer & Gold, 2012).

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