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Culturing the adolescent brain: what can neuroscience learn from anthropology?

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Cultural neuroscience is set to flourish in the next few years. As the field develops, it is necessary to reflect on what is meant by 'culture' and how this can be translated for the laboratory context. This article uses the example of the adolescent brain to discuss three aspects of culture that may help us to shape and reframe questions, interpretations and applications in cultural neuroscience: cultural contingencies of categories, cultural differences in experience and cultural context of neuroscience research. The last few years have seen a sudden increase in the study of adolescence as a period of both structural and functional plasticity, with new brain-based explanations of teenage behaviour being taken up in education, policy and medicine. However, the concept of adolescence, as an object of behavioural science, took shape relatively recently, not much more than a hundred years ago and was shaped by a number of cultural and historical factors. Moreover, research in anthropology and cross-cultural psychology has shown that the experience of adolescence, as a period of the lifespan, is variable and contingent upon culture. The emerging field of cultural neuroscience has begun to tackle the question of cultural differences in social cognitive processing in adults. In this article, I explore what a cultural neuroscience can mean in the case of adolescence. I consider how to integrate perspectives from social neuroscience and anthropology to conceptualize, and to empirically study, adolescence as a culturally variable phenomenon, which, itself, has been culturally constructed.

Keywords: adolescence; culture; context; brain development; neuroscience; anthropology

INTRODUCTION

The recent emergence of cultural neuroscience represents an important challenge to the assumption of universality of the neural mechanisms associated with perceptual, attentional and social interaction processes. New data from functional neuroimaging studies mirror findings from cross-cultural psychology research, by showing differential brain activation patterns, in terms of degree and location, among adult individuals of different cultural groups engaged in a variety of cognitive tasks (see Han & Northoff, 2008 for a review). Certainly, with the advancement of neuroimaging technologies, and the formation of new interdisciplinary fields such as social neuroscience, neuroethics and most recently cultural neuroscience, there has been a renewed interest in 'neural underpinnings' of categories, or kinds, of people. The possibility of seeing the living brain in action has stimulated a drive to characterize these categories of people—for example, male and female, Republican and Democrat, prosocial and antisocial, Eastern and Western—in terms of neural signatures. Such categories, however, are not natural kinds; they are often culturally constructed, rather than rooted solely in the body or the brain. Cultural neuroscience holds much promise for furthering our insights into the meaning of the differences it finds, and has the potential to shed light on how social and cultural contexts interact with brain development. To do this, however, as this new subfield unfolds, it is crucial to attend to how culture is conceptualized in the design and interpretation of experiments. Drawing on insights from psychology, sociology and especially anthropology will no doubt prove increasingly valuable.

In this article, I use the example of the adolescent brain to discuss three challenges for cultural neuroscience concerning categories, meaning and scientific context, which require careful consideration to 'culture' in different ways. First, I suggest that an imperative for cultural neuroscience ought to include an inquiry into historical background of the phenomenon under study and the assumptions underlying it. This would involve an awareness of how a scientific category, such as a particular distinction between people, was shaped, with what goals and imbued with which views of the person or the mind/brain. Culture in this case, therefore, refers to the values and assumptions embedded in the category of adolescence when it was originally conceptualized as an object of scientific study (Daston, 2000). Secondly, I consider how cultural neuroscience can benefit from anthropology in understanding how a given category or experience under study in the lab may have different meanings in different cultures. Here, culture refers to the way in which the developmental environment—the system of beliefs, values, languages and social setting—of the individual is organized. Developmental histories may vary

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according to differences in, for example, historical customs, child-rearing practices and aspects of physical settings (Super & Harkness, 2002). Thirdly, and related to the first point about history, I briefly discuss the need to be mindful of the broader context in which current scientific knowledge about neuroscience is generated to suggest that culture at large may influence the questions we pose in the laboratory and the applications of the data. Culture in this case refers to the larger contemporary social institutions and practices that influence, and maintain, our ways of knowing as scientists (Hacking, 2002).

THE CONSTRUCTION OF THE ADOLESCENT BRAIN: STATE OF THE NEUROSCIENCE

Thirty years ago, the brain was understood to be fixed and immutable in its final structure by early childhood. During the last decade, however brain imaging studies have suggested that cortical development is much more protracted than previously thought, and that beyond childhood the brain manifests significant degrees of malleability, peaking during adolescence and continuing during early adulthood (Gogtay *et al.*, 2004; Paus, 2005; Toga *et al.*, 2006). This may reflect human biological attunement to acquire and transmit elements of culture (Fiske, 2009). Adolescent plasticity, then, might be a period of development of cultural niches and the reciprocal shaping of the brain.

The last few years have seen a sudden increase in the study of adolescence as a period of both structural and functional plasticity (Burnett & Blakemore, 2009; Güroğlu *et al.*, 2009; Paus, 2005). One reason for this heightened interest in the adolescent brain is probably the recent availability of extensive new data sets about brain development. In the last decade, results from structural neuroimaging studies involving large samples of children and adolescents have given weight to previous smaller scale histological studies that used postmortem samples to demonstrate considerable neuroanatomical developments at puberty and beyond this stage, into early adulthood. Specifically, the neuroimaging data—from magnetic resonance imaging (MRI) and diffusion tensor imaging (DTI) studies—coupled with the earlier cellular findings (Huttenlocher, 1979) point to experience-dependent rewiring, most likely in terms of synaptic reorganization and increased axonal myelination of evolutionarily 'newer' parts of the brain, especially prefrontal and parietal cortex (see Blakemore & Choudhury, 2006, for a review). The evidence that the most pronounced developments are in brain regions associated with 'higher' executive functions and social cognition has inspired numerous studies investigating the cognitive correlates of the anatomical developments.

Data gleaned from functional MRI (fMRI) experiments suggest that the development of social emotional processing (Burnett *et al.*, 2008), regulation of emotions (Hare *et al.*, 2008), understanding of intentions (Blakemore *et al.*, 2007), assessment of risk (Bjork *et al.*, 2007), decision-making (Eshel *et al.*, 2007), cognitive flexibility (Crone *et al.*, 2006) and inhibition of impulses (Casey *et al.*, 1997; Luna & Sweeney, 2004) correlate with maturation of the brain during adolescence. Among these, risk-taking and impulsivity are two sets of behaviours that have received considerable attention in adolescent brain research. Drawing on data from *in vivo* structural and functional studies of the developing human brain, and building on animal models, this research has suggested that heterochronous development of nucleus accumbens, associated with reward prediction, and prefrontal cortex, which subserves inhibition of impulses, account for risky behaviour (Casey *et al.*, 2008). In light of the burgeoning field of social neuroscience and evidence of structural changes in the 'social brain' after childhood, the neural bases of social–emotional functioning during adolescence have recently become a new focus of research (Blakemore, 2008). Data demonstrating structural maturation in medial prefrontal cortex, parietal cortex and superior temporal cortex during adolescence correspond to developmental shifts in functional activation in these brain areas during tasks requiring self-processing, and the understanding of intentions and emotions of others. Such studies tend to suggest that the brain has a role to play in the 'turbulence' and 'storm and stress' (Hall, 1904) that typically characterize teenage life in psychological theories. The model of the maturing brain has thus served as an explanation for many teenage behaviours reported anecdotally with a number of implications for education, social and health policy.

Another reason for the focus on the adolescent brain often stated in neuroscience studies is the concern about adolescent mental health as a 'public health problem' (Steinberg, 2008). While most adolescents do not suffer from mental health problems, youth is the stage in life in which mental disorders are often thought to begin. It is increasingly speculated that the maturing brain may be of causal significance. Paus and colleagues, for example, suggest that developmental events during the maturation of frontotemporal pathways may have an important role to play in the development of schizophrenia during late adolescence (Paus *et al.*, 2008). In a recent review, Patel and colleagues have argued that in order to meet the challenge of improving mental health of young people, researchers need to take a global perspective and to pay close attention to culture in terms of both risk factors and protective factors. Cross-national epidemiological studies comparing prevalence of mental disorders in young people aged 12–24 years reveal that rates vary significantly from one country to another, from 8% in the Netherlands to 57% in the USA (Patel *et al.*, 2007). Moreover, within one country, cultural background has important influences on mental health. For example, in the UK, young people of English origin in the UK are four times more likely to suffer mental illness compared to those of Indian origin (Green *et al.*, 2005; Liem *et al.*, 2000). These cultural differences in

incidence of psychiatric disorders are relevant for cultural neuroscience. Insights from social and cultural neuroscience—with their emphases on the study of self-concept, understanding of others and emotion regulation—are frequently used to investigate the neural bases of psychiatric disorders. If a major objective of cognitive neuroscience of adolescence is to further insights into mental health (Cody & Hynd, 1999; Nelson *et al.*, 2005), studies in neuroscience that investigate cognition in typically developing adolescents need to engage with the question of culture (Choudhury & Kirmayer, in press). If cultural neuroscience is to contribute to this project, it must acknowledge and incorporate findings from anthropology that show considerable cultural variation in the transition from childhood to adulthood and, first of all, unpack the very category of 'adolescence' as we commonly know it in cognitive neuroscience.

THE CULTURAL CONSTRUCTION OF ADOLESCENCE AS A CATEGORY

In searching for biologically based explanations, scientific research has made important efforts in removing what have sometimes been insidious moral interpretations surrounding certain behavioural phenomena.[1] However, given that normative conclusions are often drawn from biological theories, thoughtful scientific inquiry into aspects of personhood, identities, life stages and cultures, specifically efforts to find their functional or anatomical correlates, requires critical reflection about the origins of the categories. There are several sociological and historical theories about the 'cultural invention of adolescence' as a category of the lifespan that emerged as a product of modernization and industrialization (Ariès, 1962; Bucholtz, 2002; Coleman, 1961). Here, I will not enter into a discussion about the many social, cultural and economic factors such as shifting patterns of family life, urbanization, changes in employment and the introduction of full-time schooling, thought to have shaped the lived experience and categorization of adolescence. Rather, in this section, I will focus on describing one major historical influence on the contemporary scientific characterization of the features and duration of adolescence, established at the turn of the twentieth century in psychology.

Popular narratives and scholarly discourses are replete with conceptions of adolescent *nature*, as a troubled transitional period. Most of the available theories about, and definitions of, adolescence as a time of turmoil can be traced back to psychological theories from the late 19th century, developed in Western Europe and the USA. These notions of adolescence stem from the work of the American psychologist G. Stanley Hall, who was steeped in a nativist view of development and concerned with the primacy of nature over nurture, and who was foundational in defining adolescence in modern, scientific terms. While some contemporary researchers challenge Hall's theories, many of the research questions including the recent focus on risk-taking in psychology, psychiatry and neuroscience reflect the legacy of Hall's view in terms of the notions of, and hypotheses about, adolescence. In his two volumes, *Adolescence: Psychology and Its Relations to Physiology, Anthropology, Sociology, Sex, Crime, Religion, and Education* (1904), Hall laid the ground for new rigorous scientific observation and description of 'adolescence . . . a new birth' (pp. xiii) and a 'transition stage [of] the soul' (pp. vii). The scientific category of 'adolescence' was developed in a particular historical moment, in which particular cultural concerns were influential in shaping it. Hall was profoundly influenced by evolutionary theory, especially, German zoologist Ernst Haeckel's theory of recapitulation (Haeckel, 1866), which proposed that individual development parallels the historical record of species development ('ontogeny recapitulates phylogeny'), a theory upon which Social Darwinism was predicated. Hall believed that 'the child and the race are key to each other' (Hall, 1904, pp. viii). This view reflected American and European sociological and scientific discourses of the time which linked the individual to society and which were deeply concerned with the progress and decline of mankind (Kaufmann, 2008). In these evolutionary terms, Hall likened children to 'savages' and adolescents to nomadic wanderers. As such, evolutionary ladders of individual psychological development from child to adult could be used to calibrate stages of development of cultures in terms of their intellectual and moral evolution. For example, in *Adolescence*, he described African, Indian and Chinese cultures as 'adolescent races', suggesting that the behaviour of these cultural groups represented arrested development. Adolescence, therefore, represented the transition from the primitive to the civilized. This recapitulative theory resonated with the nineteenth century view of the brain as an archive of the evolutionary past, in which 'primitive' limbic parts of the brain that develop first are controlled by 'higher' frontal areas that are later to develop. In all of these evolutionary theories, amongst which the scientific category of adolescence was developed, metaphors of hierarchy, ladders and transitions into civilization—of the brain, the individual, society and the human race—abounded (Gould, 1977; Smith, 1992; Young, 1990). Hall, along with other 'boyologists' and social reformers, was concerned with the transition from 'the traits of savagery' (pp. vii) during boyhood to the civilized modern man—a loyal, courageous and patriotic nation-builder. It has been argued that, at the turn of the twentieth century, a period of dramatic social change, the category of adolescence was invested with ideas that reflected preoccupations with nation building and imperialism (Lesko, 2001). Historicizing the category of adolescence that is now used

[1]For example, research in neuroscience has led to the shift towards the widely accepted explanation of autism as an organic developmental disorder, from previous psychoanalytic views that held the mother accountable.

widely to refer to an age bound period often associated with 'psychological turmoil' provides an insight into the cultural concerns that influenced its development. The category of adolescence, formed in the early twentieth century is deeply entangled with the normative and socio-economic dimensions of Western industrial societies.

While much research demonstrates that adolescence is a historical product, a recent large-scale ethnographic study has suggested that a 'social stage intervening between childhood and adulthood in the passage through life' exists across most cultures (Schlegel & Barry, 1991, p. 8). At the same time, increasing evidence from neuroscience is pointing to structural and functional changes in the brain during this period. What then does the historical construction of a scientific category mean for experimental investigation? Adolescence is of course 'real' in the sense that the category is used to organize many aspects of social life from the level of healthcare and education down to individual experiences. However, the facts about adolescence—its duration and its features—are also bound up with the social and cultural conditions in which it is experienced, studied and understood. Cultural neuroscience is well placed to deal with such contingencies by bringing an awareness of how the defining features of a category may differ depending on context, to the experimental design. It can, for example, use ethnographic data about child development, socialization processes and emotions to investigate the relationships between these culturally shaped processes and neural processes, as well as to guide the design of appropriate experimental stimuli.

COMING OF AGE: A CROSS-CULTURAL PERSPECTIVE

Research suggests that in many contemporary cultures, development does not correspond neatly with adolescence as a distinct category of the lifespan bound by ages 10 and 19.[2] For example, research carried out in Bangladesh, showed that childhood can extend up to puberty for those children attending school and without economic responsibilities, while those who enter employment are not considered children as soon as they begin to work, even if this is at the age of six (Blanchett, 1996). Other research has suggested that among the Hmong people, there is no middle transition stage between childhood and adulthood; instead at ages 11 or 12, adulthood begins as childhood ends (Tobin & Friedman, 1984). Currently, most of the data in neuroscience experiments are drawn from groups of individuals enrolled in particular schools and universities in the UK and USA, most likely representative of only certain socioeconomic status. Given the cultural differences in transitional periods between childhood and adulthood, age alone, as the defining markers of this category can therefore be inaccurate and seem arbitrary. The task of cultural neuroscience in this respect would be to investigate how neurocognitive developments interact with particular proxies of the cultural environment, and to consider when 'adolescence' as a category is useful to account for a particular cognitive difference, and if not, to conceptualize alternative variables that may relate to the cognitive process being studied.

If we assume that a transitional period of the life cycle, akin to adolescence, organized around puberty and of variable length, exists almost universally, the next question is what forms it takes and whether its features, too, are universal. Ethnographic research in Somoa conducted by anthropologist Margaret Mead brought the issue of cultural difference in the experience of adolescence to the fore. Her book, *Coming of Age in Samoa* (Mead, 1928) famously challenged Hall's 'storm and stress' model and argued that Samoan culture influenced psychological development of girls in such a way that the transition from childhood to adulthood was smooth and lacked the 'natural' turbulence with which it had been characterized by the evolutionary view. Unlike American culture, Samoan culture, she argued, did not place judgements and pressures on adolescents and was more relaxed, for example, in its views about sexuality. All of these factors were thought to make Samoan adolescence relatively tranquil and enjoyable and led to Mead's assertion of the primacy of nurture over nature. While Derek Freeman later critiqued Mead's culturally deterministic approach for a number of methodological reasons (Freeman, 1983), her ethnographic approach has been important for subsequent cross-cultural approaches to adolescence. Since then, a sizeable literature in psychology and anthropology has developed which has addressed cross-cultural differences in adolescence.

Schlegel and Barry's cross-cultural study of adolescents in tribal and traditional societies using data collected from over 175 societies around the world demonstrated that adolescence as a distinctive, socially marked stage of life is ubiquitous. These researchers put forward a biosocial theory, arguing that the social stage of adolescence is a response to the development of the reproductive capacity (Schlegel & Barry, 1991; Schlegel, 1995). Most notably, however, these cross-cultural studies challenge the notion that features of 'storm and stress' and a period of psychological crisis are universal inevitabilities in adolescence. For example, while mild forms of antisocial behaviour were present in some societies, it was certainly not generalizable as a feature. Similarly, aggressive and violent behaviour occurred in a minority of cultures and when present was heavily gendered with aggression in girls being particularly low. Cross-cultural researchers stress that the *meanings* of developmental tasks associated with adolescence such as the establishment of independence or autonomy may differ according to culture, and may be subject to change over time. For example, developing independence in some cultures may mean taking on duties to care for siblings or elders, and not necessarily

[2]WHO (2005).

separating from adults and orienting towards peers (Chen & Farrugia, 2002; Trommsdorff, 2002). Based on a study comparing five cultures that could be contrasted as 'traditional' and 'modern' or 'collectivistic' and 'individualistic', Trommsdorff suggested that 'turbulent' features such as intergenerational conflict stem from the focus on attaining independence from parents during this period and are linked to cultural values of individualism in Western societies (Trommsdorff, 1995). Certainly, in many cultures, particularly in pre-industrial societies, adolescence is not marked by such a characterization or psychological turmoil, and thus, both the characterization and length of this life stage vary according to culture. Puberty, too, which is clearly grounded in biology across cultures, interacts with the local environment. Menarche, which marks the beginning of puberty in girls, is occurring increasingly early in industrialized countries such as Japan or the USA. This finding may be connected to changes in dietary intake (Berkey *et al.*, 2000). Even if puberty could be the biological marker of the start of adolescence in every culture, the end point is less clear.

In summary, adolescence conceptualized as a prolonged period of identity development linked to increased autonomy, intergenerational conflict, peer-relatedness and social psychological anxieties, is not the norm across cultures. Indeed, these features seem to depend on degrees of individualism, social/economic role expectations, gender and class (Dasen, 2000; Saraswathi, 1999). A historical appreciation of adolescence as a category of science as well as cross-cultural investigations of the experience of adolescence demonstrates that characteristics associated with this developmental stage may not only have biological bases but also social and cultural origins. Neural differences between ages could then lead us to examine the quality of the differences in terms of the associated experience and cultural meanings.

Culture is of course a heavily contested concept. Therefore, careful conceptualization and appropriation of culture and its proxies are crucial. It is important that geography, culture, ethnicity and race are not conflated, in order to avoid cultural essentialism. Within a country and an ethnicity, there is enormous intracultural variation (Gibbons, 1998) of ways of living and thinking, while others may be shared across countries or ethnicities. The construct of race, for instance, has a political history and, as a reference to skin pigmentation, is a generally unhelpful measure of difference where neuroscience is concerned. The use of race in the brain sciences has historically been coloured by ideological motivations related to racism and colonialism. All of these, conceptualized as categories of self-contained cultures that can be used to compare groups of people in scientific experiments, are challenged by globalization. The movement of people, of ideas about ways of living and ways of being and the transmission of knowledge through various media mean that most cultural communities are increasingly heterogeneous and give rise to hybrid identities (Kirmayer, 2006). Cultural neuroscience must acknowledge these changes and look for meaningful and measurable proxies of culture that cut across fixed, geographically bound conceptions of culture, and bear relevance to young people in increasingly fluid and diverse contexts. Such proxies may, for example, relate to measures of individualism/collectivism, interaction patterns with others, family size, diet, aspects of personality, caregiving, life stresses, or school settings. For example, a number of studies among Argentinian infants, US American children and adolescents, British and Finish adults using both behavioural and neuroimaging methods indicate that poverty—indexed by various measures such as personal and family income—is negatively correlated with performance on executive function and memory tasks (see Hackman & Farah, 2009 for a review). The causal relationship between socioeconomic status and differences in neurocognitive function is an important topic for future research.

Anthropology has generated a very complex discourse of culture, and it is exactly such complications cultural neuroscience needs to consider when designing and interpreting experiments that investigate the interaction between brain function and (some aspect of) culture. Super and Harkness (2002), for example, propose that culture 'is usefully conceived . . . as the organization of the developmental environment' (p. 270). They conceptualize culture as operational in three subsystems—(a) physical and social settings, (b) historically constituted customs and practices and (c) child rearing and the psychology of caretakers. The physical and social settings are the settings of daily life for example patterns of sleep and wakefulness, degree of early gender segregation, the amount/type of verbal interaction directed towards infants by caregivers. Historically constituted customs can be construed as community-wide solutions to child rearing, for example adult circumcision rituals in certain African cultures, or more routine, how to carry babies to keep them out of danger. The final subsystem is the psychology of the caregivers including beliefs concerning the needs of children and the community goals of child rearing. All of these aspects of culture are likely to influence cognitive development in adolescents. Indeed contemporary cross-cultural psychology research demonstrates that emotional understanding (e.g. Liem *et al.*, 2000), moral reasoning (e.g. Skoe *et al.*, 1999), behavioural inhibition (e.g. Rubin, 1998) and self-concept (e.g. Kuebli *et al.*, 1998; Offer *et al.*, 1988) in adolescence vary in different cultures.

More recent neuroimaging studies have shown that the neural structures supporting self-processing develop during adolescence, and their maturation may reflect different cognitive strategies in self-related judgments (Pfeifer *et al.*, 2007; for a review see Sebastian *et al.*, 2008). However, self-construal is strongly contingent upon culture with varying emphases placed, for example, on individuality, social, environmental and spiritual connectedness with

styles of child-rearing having a strong role in shaping 'cultural selves' (Quinn, 2003). For example, Japanese infants are born into a culture where the self in a social matrix frequently comes before the self as an individual. Accordingly, naturalistic behaviour studies have shown that American children at 2.5 and 6 years exhibit more independence-related behaviour than their Japanese counterparts, who exhibit more interdependent behaviour (Caudill & Schooler, 1973). Neuroimaging studies have shown that in adults, the neural systems associated with representations of the self, relative to others, are modulated by culture (Chiao *et al.*, 2009; Han & Northoff, 2008; Kobayashi *et al.*, 2007; Zhu *et al.*, 2007). The cultural differences in brain activation were interpreted in light of differences in individualist and collectivist cultures and their constructions of the self. Specifically, in individualists (as indexed by a questionnaire) the neural activation pattern was more distinct for the self and other, and in collectivists the activation patterns overlapped. It is also likely that culturally shaped ideas of the person influence the development of cognitive and neural processing of self during adolescence. One task for cultural neuroscience to avoid reifying cultural stereotypes in the lab, is to recognize the heterogeneity of cultural values within groups, for example within 'Western' and 'East Asian' groups as have been compared in recent studies.

In addition, cultural neuroscience needs to unpack concepts such as 'self' and 'moral reasoning' and acknowledge cultural differences in their very construal and in the way that they may be experienced. Designing paradigms that tap culturally relevant meanings of the concept under study is an important challenge for future studies. As some researchers have pointed out, 'to explain what is going on *in* the black box is not to explain what is happening *for* the black box' (Zahavi, 2004). Experiments in cultural neuroscience focusing on adolescence would benefit from additional methods to incorporate the structure of first person experience in ways that can be categorized and validated to understand how neurophysiological processes in the brain relate to what is happening *for* the adolescent (Gallagher, 2003). Triangulating on complex cognitive processes such as those involved in social cognition, by bringing together multiple levels including functional and structural MRI data, behavioural data as well as introspective reports, may provide richer insights into the meaning of differences in brain structure or function during development, and indeed in studies aiming to compare groups in cultural neuroscience studies. Retrospective reports can gauge several aspects of the task not captured by standard reaction time or BOLD responses to stimuli, such as the participant's understanding of the task, strategies employed, and a broad picture of the subjective experience of performing the task (Jack & Roepstorff, 2002). Such introspective reports might be especially helpful in making sense of group differences when performance levels are comparable, for example between age groups in developmental studies, but when neural activity differs.

BIO-LOOPING AND NEUROSCIENCE IN CONTEXT

Biological approaches to culture are certainly not new, and the field is marred by a difficult history. Scientific approaches to culture are clearly shaped by culture at large, and have in the past depended on ideological and practical motivations. A critical, that is, reflexive, cultural neuroscience, must acknowledge and examine the links between the cultural context in which neuroscience is practiced and the object of neuroscientific inquiry, itself (Choudhury *et al.*, 2009). Cross-cultural psychology has already shown us that cognitive phenomena are shaped by social and cultural contexts of the person (Nisbett & Miyamoto, 2005). Cultural neuroscience has corroborated this in showing that the functional activation of neural structures supporting these cognitive processes is also modulated by cultural context (Han & Northoff, 2008). Scientific inquiry, including the making of neuroscientific knowledge, is itself a cultural activity, shaped by a number of social, economic and political factors, including the concepts employed in experiments, as described above. Neurocognitive phenomena, that is, the brain-based explanation as well as the actual observed neural processes and corresponding behaviour, are therefore shaped by systems of neuroscientific reasoning and methods of observation at any given moment. The epistemic culture of neuroscience in this way influences both the hypotheses and interpretations (Knor-Cettina, 1999; Young, 1995). From the research questions thought to be interesting, useful and worthy of funding, the assumptions about concepts and categories scientists work with, to what technologies are considered more objective and the potential applications of the findings, neuroscientific phenomena are subject to a range of cultural determinants beyond the laboratory.

Objectifying an identity, stage of life, culture or behaviour in terms of the brain interacts with the experience (and likely, the neural correlates) of that which is classified. Philosopher of science, Ian Hacking has called this kind of interaction between classification of people and their ways of being the 'looping effect of human kinds' (Hacking, 1995). Here, this idea of looping by no means aims to pit a constructivist argument against a realist science. Rather, it holds that while neuroscience reveals real phenomena about behaviour and its instantiation in the brain, the cultural context of neuroscience interacts with scientific knowledge claims and influences the experience of the people to which they pertain (Hacking, 2002). To give a concrete example of bio-looping, in psychiatry, the interaction of social and cultural processes that shape an individual's understanding of, and attention to, the body directly interacts with the experience of (and possibly biological reflections of) particular symptoms in psychopathological phenomena (Kirmayer *et al.*, 2004; Kirmayer, 2005). In the case of

adolescents, it is possible that culturally and historically shaped concepts of normal adolescence used in science, defined as a transition period of emotionality, risk taking and so on, create a space of possibilities of how to be, with which young people can constitute themselves, and which may in turn be encoded in the brain. Characterizing these behaviours in terms of the brain has the effect of reifying the classification, stabilizing it both as a neuroscientific phenomenon and a way to be an adolescent (Males, 2009). Recognizing that neuroscience itself is a cultural activity that may influence those under study by utilizing concepts and ways of seeing that are culturally and historically contingent reminds us that culture is not a 'thing' or an essence located in the brain that can be 'revealed' by neuroscience. Finally, it is important to acknowledge that adolescents are also producers of youth cultures, whose behaviours are not simply a consequence of being positioned within culturally or biologically sanctioned life stages (Wulff, 1995).

THE FUTURE: THE ENCULTURED BRAIN

In this article I have drawn together insights from multiple disciplines to propose initial ideas about how cultural neuroscience can approach the subject of adolescence. Such an approach would recognize the many origins of adolescent behaviour, from the historical roots of 'adolescence' to the plastic nature of the brain, the dynamic social environment and the cultural scripts of adolescence, all of which shape subjective experiences of adolescence as well as knowledge about adolescence.

I have suggested, using available data from psychology and anthropology, that psychological turmoil is not an inevitable aspect of adolescence driven by the brain, across cultures. Rather, historical and ethnographic research demonstrates that the duration and characterization of adolescence are culturally contingent. Features such as risk-taking and increased incidence of psychopathology are certainly thought to be associated with adolescence in many cultural contexts. While existing neuroimaging studies of brain development in Euro-American contexts may demonstrate biological reflections of developing cognitive skills pertaining to these features, these differences do not demonstrate neurobiological causes of universal problem behaviours. The differences found in these studies can instead open up new questions and lead us to study more closely the contextual and experiential correlates—including socialization processes, economic roles, family roles, social and economic disparities—of these neural differences, by breaking down 'culture' into a number of possible indices, beyond just ethnicity or geography. Nuanced conceptualizations of culture will help to develop our understanding of the knowledge, schemas and practices associated with neural differences.

How can cultural neuroscience work within a framework that does not give primacy to either the brain or culture? One possible way is to blur the common distinction between 'nature and culture', or the brain and culture, and integrate an understanding of neurocognitive mechanisms with the social and cultural practices in which they are embedded. If the brain is in constant interaction with its context, then such dichotomies are untenable. Certainly, recent advances in genetics demonstrate clear bidirectional interactions between the brain and environment during development (e.g. McGowan *et al.*, 2009). Cultural neuroscience must work towards developing an integrative explanation of how 'meaning and mechanism' intersect via the brain (Seligman & Kirmayer, 2008), and how this subsequently shapes behaviour. This echoes the social ontology of neuroarchaeology (Gosden, 2008; Renfrew *et al.*, 2008), an interdisciplinary approach that emphasizes a 'brain-body-world' interaction in which none is causally determinant, but rather holds that human experience unfolds through an equal input from materials in the world and people. With respect to adolescent cognitive development, the corresponding developmental view of 'bio-cultural co-constructivism' (Li, 2006) usefully captures the interaction between the brain and culture in guiding cognitive development. Social neuroscience demonstrates that humans are endowed with certain neural dispositions to social stimuli and that the functional activity of the associated brain areas may shift during development. Cultural neuroscience might take this further to examine the interaction, reinforcement or 'looping' between processes that are neurally instantiated and those that are culturally scripted, during development.

The idea of studying brain–world interactions is certainly not new to neuroscience—there is, for example, a wealth of data demonstrating the interaction between the visual cortex and the environment, pointing to the role of the environment in shaping brain structure and perception. In this case, however, culture, arguably the most important part of the human environment, is particularly complex, especially in a globalized world. The way in which culture is measured and understood in the lab, therefore, requires careful scrutiny. Studying (the development of) the 'enculturated brain' (Lende, 2008) requires a genuinely interdisciplinary approach. Cultural neuroscience is already building on findings from cross-cultural psychology. Bringing together methods and theory from anthropology promises to enrich experimental design and interpretations in cultural neuroscience. Transcultural brain imaging provides useful information about how individual brain function may be modulated depending on an aspect of culture. However, what are the real world thoughts, events, meanings and experiences that correspond to these neurophysiological processes? Pursuing the answers to this question requires a cultural neuroscience that incorporates insights from multiple disciplines to investigate the way in which behavioural phenomena are connected across many levels—neural processes, cognitive phenomena, culturally shaped behaviours and expressions—and recognizes the many locations of

culture that shape the cognitive processes we study, and the way in which we study them.

Conflict of Interest

None declared.

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