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EDUCATIONAL RESEARCHER 2010 39: 643

DOI: 10.3102/0013189X10392139

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2010 Presidential Address

Soaring Above the Clouds, Delving the Ocean's Depths: Understanding the Ecologies of Human Learning and the Challenge for Education Science

Carol D. Lee

This article was originally the presidential address for the 2010 annual meeting of the American Educational Research Association. It offers three orienting ideas drawn from across human development, neuroscience, cognition, and cultural psychology, as well as studies of biological systems: (1) the intertwining of culture and biology in human development, (2) adaptation through multiple pathways, and (3) interdependence across levels of context. The author argues that these orienting ideas provide warrants for a dynamic view of human learning and development, rooted in both human biology and culture. Implications for research and practice are discussed.

Keywords: at-risk students; cognitive processes/development; cultural analysis; human development; neuroscience

The theme of the 2010 AERA annual meeting is "Understanding Complex Ecologies in a Changing World." This theme represents a conundrum that we face as a nation, as educators, and as education researchers. I have been wrestling with this question for nearly a decade. From 1995 to 1998, some colleagues and I engaged in an intervention in an underachieving high school in Chicago, working with the English department to teach skills of literary analysis by drawing on the everyday metalinguistic knowledge of speakers of African American English in a process that I have come to call Cultural Modeling (Lee, 2007).

Yetu was an exceptionally bright young man in my freshman class who contributed substantively to the class's argumentation over the meaning of texts (Lee, 2001). He was quiet and introspective. I met his parents, who were very engaged in his development. By the time Yetu was a sophomore, he was the father of twins. By his junior year, one of his twin babies had died and he had been kicked out of school, suspected of selling drugs. It became clear to me that our culturally responsive literacy intervention, while effective in its own limited goals, was not sufficient to address the

challenges Yetu faced. I wrestled with the question of what array of safety nets would have been needed to help avoid what happened to Yetu.

During this same period and subsequently, I cotaught a seminar at Northwestern University with colleagues from the university's Human Development Program (a sociologist, Gunhild Hagestad, and human development scholars Philip Bowman and Bart Hirsch). In my own research, I had drawn on studies in cognition, language socialization, and literary analysis to inform the design of the intervention in the Chicago high school, but now I began to read across literatures in human development. This broadening of the intellectual repertoires upon which I could draw led me to ask a different set of questions about Yetu:

- *What in particular about Yetu's being an adolescent—and specifically his being a Black male adolescent—mattered for the challenges he faced, for how he made sense of those challenges, and for the resources available to him to address the challenges?* Translation: What did we need to know about role strains associated with life course development, about the various identities that Yetu embodied (as a person of African descent, as a male, as a Black male, as a student, as a father, as a son)? And in what ways did his personality traits (i.e., quiet and introverted) intersect with his conceptions of what it meant to be a man in the becoming, and a Black man in particular? (See Bowman, 1990; Bowman & Howard, 1985; Boykin, 1986; McAdams & Pals, 2006; Spencer, Fegley, Harpalani, & Seaton, 2004.)
- *What role did or could the various settings in which Yetu routinely participated play both in shaping the challenges he faced and in providing resources (positive and negative) for how he responded: his immediate and extended family, his social networks of peers and adults outside his family, the school, the church, and community organizations with which he was or was not affiliated?* Translation: How could we think about Yetu's development beyond a focus on his individual characteristics (i.e., his individual cognitions, his individual social and emotional states and dispositions, his own physical health and physiological functioning)? How could we shift to a focus on

understanding Yetu in relation to the multiple contexts in which he routinely participated (Bronfenbrenner & Morris, 1998; Spencer, 2006)? Was it solely the responsibility of his family or solely the responsibility of the school to have anticipated the vulnerabilities of this young man? Is it possible that access to resources (i.e., knowledge, relationships, belief systems, physical resources) in any one or more of these settings could have buffered or moderated the negative outcomes he faced?

- *What role might larger macrolevel policies, belief systems, and institutional configurations have played in shaping the particular challenges Yetu faced and his response to those challenges?* Translation: What roles were played by the historical underfunding of his high school; the policies and practices that led to a concentration of teachers who were not prepared to teach Yetu; district-level policies that helped to shape the discipline practices at the school; the media stereotypes (in music, television, films, popular magazines) that reified particular visions of manhood, popularity, and material success; historically sustained stereotypes with regard to being Black and being a Black male that manifested themselves in multiple face-to-face microaggressions between Yetu and teachers, security guards in the building, police in his neighborhood, and male peers at school and in his neighborhood? (See Brooks-Gunn & Duncan, 1997; Darling-Hammond, 2010; Eccles, 2005.)

I then began to reflect on the kind of orientation to Yetu's development that much of the research across the social sciences would lead me to (e.g., in cognitive studies of learning; in human development research on issues of identity, social and emotional development, and motivation; in sociology on the consequences of class stratification and positioning with regard to race and ethnicity). I have concluded that the meta-narrative about the Yetus of the world is largely deficit oriented (Graham, 1992), focusing on risks rather than resilience (Spencer et al., 2006), on static assumptions about ability (Dweck, 2002), and on homogeneity rather than variation (Gutierrez & Rogoff, 2003). We typically examine the world through our disciplinary silos, focusing on single institutions as opposed to people's movement across settings, on either cognitive or psychosocial functioning as opposed to their intersections. Rarely do we focus on intersections across the cognitive, the psychosocial, and the physiological. I am convinced that there is no singular lens through which to deconstruct Yetu's dilemma; rather, his challenges and decisions must be understood inside a complex and dynamic ecological system.

As I have wrestled now with the challenge of understanding and examining complex human ecologies, I have begun to extend my study of cognition and human development to include what I think are interesting insights to be had from studies of biological systems, not only because such systems are complex but also because the biological systems of living organisms are inherently structured yet entail significant biodiversity. I have begun to stretch my thinking in this direction because I believe strongly that among the most central questions we face in the social sciences, and especially in what I will call here the education sciences, is to understand the cultural variation within and across human communities; relationships between individual functioning and social, physical,

and material contexts; and what is entailed in people's moving within and across various routine settings (Nasir, Rosebery, Warren, & Lee, 2006). To do this kind of work, we will have to create venues through which we can begin to interrogate the long held, often unstated beliefs about difference that have for so long informed our studies. More often than not, our social sciences—particularly with regard to learning and development—have positioned studies of cultural diversity as an interesting sidebar but not central to basic studies of human functioning (Lee, 2008). This I think is evident in the way that major handbooks across our fields do not integrate attention to cultural diversity into core topics, but rather segregate such discussions to an isolated chapter here or there. There are many reasons why we need to attend to cultural variation, including increased cultural diversity in the country, increased economic competition, and the demands of civic engagement; but I want to offer a complementary argument: namely, it makes for good science. This is our challenge if we want to aggregate knowledge across fields and make generalizable claims that have sufficient ecological validity to create traction in the world. So in this essay I want to share with you what I have taken from my forays into human development and studies of biological systems of living organisms, which I think offer interesting orientations for how we conceptualize diversity within and across ecological contexts.

First Orienting Idea: The Braid of Human Culture and Human Biology

The first idea I want to discuss has to do with the ways that human culture and human biology are interwoven. The metaphor I have taken from Edward O. Wilson (1998) is that of a braid. Much of the argument in this section is taken from Wilson's (1998) book *Consilience: The Unity of Knowledge*. The threads of the braid represent biological and cultural processes. But the braid is the outgrowth of their intertwining. We might think of the braid as life itself. Figure 1 illustrates four threads in the braid: physiological systems, environmental stimuli, cultural practices, and human dispositions.

We may, for purposes of a particular kind of analysis, separate the threads of the braid, but human functioning cannot be understood in its wholeness without understanding how these threads of biology and human culture work in tandem. Our biology encompasses physiological systems that allow us to experience our environments, make sense of them, and respond to them. These physiological systems include a multitiered system of interlocking levels from our DNA to our genes, cells, organs, and body systems (e.g., neurological, cardiovascular, metabolic). The development of these systems across the life course matters. Environmental stimuli are both biological and cultural. They include the sensory (e.g., living in the Arctic or near the equator), the cognitive (e.g., challenges to do things that require thinking rather than automatic, purely instinctual responses), and the chemical (sources of nutrition that provide energy for our cells as well as environmental chemicals that subject our bodies to risk). Cultural practices include organized belief systems, knowledge, institutional practices, and material artifacts created by human beings to navigate the world around us, all occurring over multiple time frames—moment by moment, over our lifetimes, and across historical time (Cole, 1996; Geertz, 1973). We have dispositions as humans that are an outgrowth of both our biology and our culture. These dispositions can be found, broadly

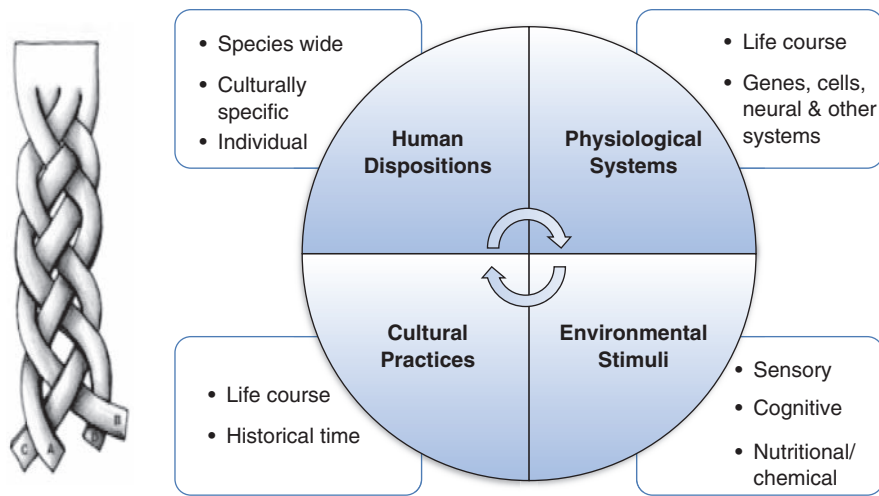


FIGURE 1. *Threads in the braid of culture and biology.*

speaking, across the human species, while at the same time they vary substantively in their expression and function by both cultural communities and individual differences (Rogoff, 2003). My point is simply that each of these threads is informed by both culture and biology and that the threads coordinate as a system of human functioning, affecting what we do and how we do things.

This list summarizes the first orienting idea:

- Humans as a species have certain *predispositions* that have their genesis in our biology but vary in expression due to differences across cultural communities.
- Because both the presence and the *diversity of expression* of these dispositions have their genesis in both human biology and human environments, our efforts as educators to understand and influence what humans learn and how they develop must take into account these predispositions as well as the diversity of their expression.
- Diversity across human communities, as with biodiversity in the ecosystems of other living organisms, *serves a creative function in terms of adaptation*.

This first orienting idea is important. It says that cultural variation is central to understanding human functioning, and that it arises from dispositions that are ubiquitous in our species. This entails the joint focus on the etic and the emic, what is common across human communities as well as what varies. We have extensive evidence of the ways in which traditional psychological sciences have articulated claims about human functioning based on restricted samples from the White middle class (Graham, 1992). The first orienting idea implies a joint functioning of the etic and the emic in cognition, psychosocial development, and physiological functioning. Wilson (1998) puts it this way:

Animals and humans are innately prepared to learn certain behaviors, while being counter prepared against—that is predisposed to avoid—others. The many documented examples of prepared learning form a subclass of *epigenetic rules*. As recognized in biology, epigenetic rules comprise the full range of inherited regularities and development in anatomy, physiology, cognition and behavior. They are the algorithm of growth and differentiation that create a fully functioning organism. (p. 150)

While Wilson attends less to psychosocial dimensions, what we know from neuroscience about the functional relationships between parts of the brain that focus on emotions and cognition certainly suggests that psychosocial development is intricately part of the equation of human functioning (Nadel, Lane, & Ahern, 2000; Ortony, 1979; Ortony & Turner, 1990; Zajonc & Marcus, 1984). And all of these biologically generated human dispositions are informed, in fact co-constituted, by our participation in cultural practices.

Human Dispositions

There are universal categories of practices of communities that can be found across cultures. These include, but are not limited to, kinship groups, age grading, marriage, postnatal care, and property rights, to name just a few (Wilson, 1998). The argument is that these universal categories of social practices are ones toward which we are predisposed by our biology. For example, across cultures smiling serves as an indicator of friendliness, approval, and a sense of pleasure (Eibl-Eibesfeldt, 1979). Smiling seems to have a relatively universal pattern of development from 2 to 4 months of age and occurs within the same parameters among deaf and blind infants (Wilson, 1998). Humans apparently have what Wilson (1998) calls an “audiovisual bias” (p. 152), such that infants from birth pay special attention to human faces over objects and distinguish their mothers’ faces and voices within 2 days of birth (Johnson & Morton, 1991). There have even been studies showing that babies in utero can at some point distinguish their mothers’ voices from voices of other women (Wilson, 1998). Across languages, two thirds to three fourths of words capturing sensory impressions refer to hearing and vision (Wilson, 1998).

Our biology predisposes us in certain ways, but our participation in cultural practices and the accompanying stimulation within our physical environments (sensory, intellectual, nutritional, chemical) influence the range of variation in how biological dispositions toward certain classes of behavior present themselves and in the meanings associated with them. In the next two sections I will discuss examples of how biological capacities and dispositions are shaped by culture.

Perceptions of and Attributions to Color

This first example involves how we as humans see color. Our genes function to allow us to perceive different wavelengths of light. Cone cells in our retina are sensitive to different spectrums of blue, green, yellow, and red (Lumsden & Wilson, 1983). It is important to note that not all light spectrums are visible to humans and that there some animals do not perceive what we call *color* (e.g., dogs). However, the ways that cultural communities capture hues reflects both variation and stability. As Wilson (1998) notes,

In simple language, our genes prescribe that we see different wavelengths of light in a certain way. Our additional propensity to break the world into units and label them with words causes us to accumulate up to eleven basic color units in a particular order. That, however, is not the end of the story. The human mind is much too subtle and productive to stop at eleven words that specify different wavelengths. . . . Color terms are often invented to include other qualities as well, particularly texture, luminosity, freshness, and indelibility. (p. 163)

In addition, through participation in cultural practices, communities construct cultural meanings associated with colors. For example, the use of the red hat or *galero* worn by Catholic cardinals or the colors in national flags and sports paraphernalia all have metaphoric significance. Indeed, historically held belief systems are also encoded in the associations we make with color. For example, Joyce King of Georgia State University and Hasimi Maiga (2005) of the University of Bamako, Mali, have documented the differences in associations with the color term *black* in U.S. English and in the Songhay language of Mali. In U.S. English we have the negative associations with *black*, such as *blackball*, *blacklist*, *black mark*, *black sheep*, and so on. In contrast, in the Songhay language, Maiga (2005) explains, *black* has positive connotations that embody important cultural knowledge, as in “black water,” “black earth,” and “black sun” (p. 174), all positive metaphors of blackness. These abbreviated examples are intended to illustrate the intertwining of the biological and the cultural in perceptions of and attributions of color.

Other Dispositions: The Physiological and the Cultural Intertwined

We have an abundance of research in the field of human development documenting the importance of relationships, attachments, a sense of competency, and a sense of efficacy for human well-being (Bell, 2010; Bowlby, 1969; Maslow, 1954; Miller & Rodgers, 2001). It is important to note that there are biological mechanisms through which we experience both the positive and negative emotions associated with relationships and our sense of competence and efficacy (Nadel et al., 2000). Our perceptions of experience trigger chemical responses in the brain such that we have an embodied response to psychological pleasure or pain (Schulkin, Gold, & McEwen, 1998). You will recall earlier my brief discussion of how infants fixate on human faces over other objects. The whole field of social cognition (Flavell & Miller, 1998) and the emerging field of social neuroscience (Cacioppo, 2002; Cacioppo & Berntson, 2004) document how humans

focus on learning to read the internal states of other human beings. It is what we impose as patterns of meanings on our experiences in the world that we store in long-term memory and use to make predictions whereby we can navigate and anticipate the potential meanings of new experiences. According to Quartz and Sejnowski (2002),

The VTA [ventral tegmental area of the brain] and related structures are your internal compass. It fills your world with values, provides emotional tone to your experiences, helps you decide what fork in the road to take when you face decisions. It is your internal guidance system, creating desires, propelling you to action, and helping you get on in the world by predicting the benefits of possible decisions. (p. 91)

In addition to the dispositions to form human attachments and to impose meaning on experience that entail embodied responses, we are hardwired to learn and use language. Language is one of the primary tools we use to encode the world of experience. We are born as infants with the capacity to hear all the sounds of all human languages, but over time we prune neural connections to the sounds of the language or languages we hear (Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Kuhl & Rivera-Gaxiola, 2008; Streeter, 1976). The point here is that these dispositions are a consequence of both biology and culture, intertwined as the braid through which human functioning takes place.

I argue here for the intertwining and indeed interdependence of biology and culture in human development, for several reasons. The tendency in social science and psychological research historically has been, and still is, to use biological explanations to reify deficit explanations of cultural difference. Many researchers who do attend to cultural variations as indicators of adaptive processes eschew attention to biological influences, in large part because biological explanations historically have been used as presumably “scientific” reifications of difference as deficits. And yet new evolutions in neuroscience, in studies of relationships between physiological functioning and cognition, especially when combined with older research in human development about the foundational role of attachments and perceptions, offer interesting new possibilities for a more unified set of theories about the multidimensional nature of, and the expansive variation in, human functioning (Bransford et al., 2006; Spencer, 2006; Spencer et al., 2006). Such an understanding suggests to me that we need to pay explicit attention to what we know about fundamental human dispositions in designing and implementing robust learning environments. At the same time, this knowledge must be tempered by understanding of the variation in how such dispositions may present themselves and be socialized (Lee, 2008). Dispositions toward functioning in social groups and the importance of attachments in such groups are universal, but how social groupings are organized and toward what developmental ends vary substantively (Rogoff, 2003; Super & Harkness, 1986). It turns out that our biggest points of contention have to do with what we make of cultural variation. One worrisome development is the current tendency to use studies of brain imaging and structural functioning to cast children and adolescents from low-income backgrounds as having deficits in language functioning, presumed to be predictive of

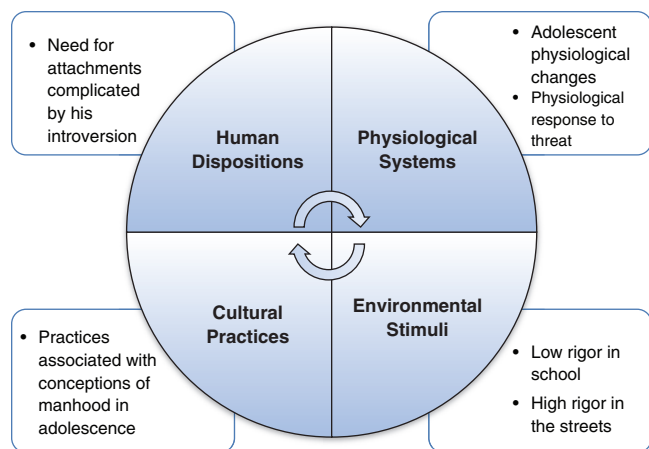


FIGURE 2. *Dynamic and intertwined systems in Yetu's development.*

reading abilities; and some measures of attention and executive control are aimed at the same set of deficit explanations. If adaptation and plasticity are characteristic of human brain functioning, then why are we not doing more to understand the conditions of such adaptation and plasticity, particularly with regard to those who face the greatest exposure to threats or obstacles in our society (Spencer et al., 2006)?

I will now take my observations about Yetu and link them back to the threads-in-the-braid metaphor. My discussion is illustrated by Figure 2.

As I have tried to describe, each of the threads (human dispositions, physiological systems, environmental stimuli, and cultural practices) has both a biological and a cultural influence. These are not linear influences but, rather, dynamic, intertwined influences working in tandem. In terms of physiological systems, Yetu's body is undergoing the greatest changes since his development as a young infant. These physiological changes exacerbate the human dispositions with regard to attachments. His need for attachments, especially attachments associated with his evolving sexual identity, are complicated by his personality traits of introversion (which undoubtedly also reflect biological influences). The confluence of physiological changes and complex negotiations around attachments, in this case with both males and females, takes place within an ecology of cultural practices and environmental stimuli. How Yetu navigates cultural messages around what it means to be a man, what it means to be a Black man, are influenced by the kinds of attachments he has with family, with adult men, with his teachers and his peers. And the meanings of these attachments are influenced by his personality and what exactly is happening in his body, at this point in his life course but also at the moment of any face-to-face interaction. The environmental stimuli in this ecology involve a difficult set of tensions between the low level of expectations that characterize participation in almost any activities in his school (despite the presence of a culturally responsive intervention in the English department, which represents at best 1 hour of his 6- to 7-hour school day) and the high and immediately consequential requirements of navigating the streets around the school and his family home. These influences on Yetu's development at age 16 do not

operate as separate silos, but as an integrated, interwoven system of activity, even if we choose as researchers to examine only one of the ecological factors.

Second Orienting Idea: Adaptation Through Multiple Pathways

Adaptation Within Ecological Environments

The second orienting idea summarizes what has struck me most profoundly in my readings about living biological systems. Living organisms—viruses, plants, animals, and the animals we know as humans—have an innate predisposition to survive. Survival depends on the ability to negotiate the demands of one's environment, including environments that are shifting. Some living organisms—not just as individuals but as species—seem to have a sense that survival means survival across generations, even at the cellular level.

Two characteristics that serve as important resources for survival are the ability of the organism to adapt and the availability of multiple pathways through which the organism can accomplish goals in the world. I have taken the idea of adaptation through the availability of multiple pathways as the big idea here.

The title of this essay, "Soaring Above the Clouds, Delving the Ocean's Depths," came to me while riding in an airplane from the West Coast back home to Chicago. In that ethereal moment, I appreciated the meaning of biodiversity, which makes birds much better at flight and fish much more adept in the ocean than we are; and at the same time, I recognized there is something special about humans in that we are able to navigate both the skies and the ocean depths, albeit not with the same dexterity as the animals for whom the sky and the ocean are their ecological niches. And we can soar above the earth at distances far greater than any bird.

In 2009, in honor of Earth Day, the Disney company made a wonderful film called simply *Earth*. It traced the first year of life of animals of several species. Animal families of adults and children managed the dual demands that face all living creatures, including human beings—that is, to teach the young what they need to learn to survive and prosper, but to do so in the midst of an environment that poses significant life-course challenges and is also in the midst of change. We see a mother polar bear and her cubs emerging from their winter den as the season shifts from 24-hour darkness to spring daylight in the Arctic. But the ice caps that historically have provided a stable, although always dangerous, place on which to stand to hunt for food are melting from global warming. And the mother bear must teach her young how to survive and navigate. We see the social organization of herds of gazelles and elephants as they migrate long distances in search of water sources that should open up with the advent of spring. They must both teach and protect their young while they migrate thousands of miles across grasslands and ward off natural predators. Both the hunters and the hunted must struggle with the drying of the savannahs.

I found interesting the examples of how, even among animals, attachments can positively and negatively influence risky behaviors. Through a combination of a built-in will to survive and engagement in social relationships with others in the group, certain animal children are willing to take risks (e.g., the baby

mallard ducks who risk jumping from their tree nests for the first time when they don't yet know how to fly; the baby elephant blinded by the sand in a dust storm with its mother, both lost from their herd, exhausted and scathingly hungry, pushing on).

These examples may seem self-evident. However, the importance of attachments and social bonds for influencing risky behavior does not seem to play a central role in how we conceptualize reform in underachieving schools (whether we're talking about risks associated with positive outcomes, like struggling as a student when problems are difficult in your algebra class or struggling as a new teacher when your students are not responding; or risks associated with negative outcomes, like engaging in group violence, as happened in the death of Albert Derrion, a young African American teenager beaten in 2009 by a mob of his peers on the south side of Chicago, in broad daylight; see http://articles.chicagotribune.com/2009-09-26/news/0909250431_1_honor-roll-youth-worker-streets).

So what does this idea of adapting to changing environments mean for Yetu? There are shifting ecologies that are most relevant to my anchoring case of Yetu—Yetu as emblematic of the life opportunities of Black and brown youth from low-income communities in the United States. One example of shifting ecologies is transmigration in the United States (and many other countries around the world), such that identities related to citizenship, language, and politics become more complex (Portes & Rumbaut, 2001; Suarez-Orozco & Qin-Hilliard, 2004; Valenzuela, 1999). In the Black community in the United States, the increased immigration of continental Africans, along with Black Caribbeans, has expanded conceptions of what it means to be African American (Dodoo, 1997; Foner, 1987; Gibson, 1991; Rong & Brown, 2001).

Present-day ecological shifts in relations between people, ideas, and institutions within and across all kinds of spaces create a world that is much more complex for young Yetu than the world I entered at 16. The ideas and relationships that can influence Yetu's identity are much more distributed and contested. The resources available to him to gain knowledge that he can use to create work and economic opportunity are both more competitive (e.g., he must compete with workers, both high tech and low wage, from around the world) and more expansive and distributed. The consequences of his health status can be more severe because of the rapid spread of viruses and other environmental hazards across the globe. At the same time, the possibilities of his fending off such hazards are undoubtedly greater than at any other time in human history because of medical advances; and yet the historically inherited beliefs, public policies, and institutional arrangements rooted in the continued presence of racism and class biases in U.S. society increase the likelihood that Yetu will have more restricted access to comprehensive health care.

These all represent significant shifts in the social, physical, economic, and political spaces in which Yetu routinely participates, as well as shifts in other spaces that affect Yetu even though he does not directly participate in them (Bronfenbrenner & Morris, 1998). I have tried to argue throughout this essay (and to emphasize in the theme of the 2010 AERA annual meeting) that we can neither understand nor influence events such as what happened to Yetu at Fairgate High School without considering broadly how the systems surrounding them operate.

Adaptation Through Multiple Pathways

The other big idea I have taken from these readings is the idea of multiple pathways as alternative mechanisms through which adaptation is possible. I have been interested in the idea of adaptation through multiple pathways because in the social sciences, particularly with regard to the education of youth who are Black, brown, and/or poor, we tend to focus on singular pathways as possibilities for adaptation. I argue that adaptation through multiple pathways is central to understanding human functioning, in part because this phenomenon has biological, environmental, and cultural foundations. Again, its ubiquitous presence says to me, we need to pay attention.

I will illustrate the idea of multiple pathways of adaptation with an example of how genetically engineered capacities are intertwined with participation in cultural practices and the attendant physical environment, as demonstrated in the emerging field of epigenetics. As John Cloud (2010) explains in simple language in a recent *Time* article,

At its most basic, epigenetics is the study of changes in gene activity that do not involve alterations to the genetic code but still get passed down to at least one successive generation. These patterns of gene expression are governed by the cellular material—the epigenome—that sits on top of the genome, just outside it (hence the prefix *epi*-, which means above). It is these epigenetic “marks” that tell your genes to switch on or off, to speak loudly or whisper. It is through epigenetic marks that environmental factors like diet, stress and prenatal nutrition can make an imprint on genes that is passed from one generation to the next.

This phenomenon can be illustrated with several foundational studies and well-established findings. I'll start with a very abbreviated description of how our perceptions of the experience of stress (which is produced by environmental stimuli) are embodied in our physiological response to stress and the impact on health outcomes—and, most astounding, the impact on how our learned and physically embodied responses to stress can be passed down across generations.

Emerging data strongly suggest that genes that provide us with the physiological structures for responding to stress can be turned on or off by experience and that such epigenetic changes can be passed on across generations (Russo, Martienssen, & Riggs, 1996; Szyf, Weaver, & Meaney, 2007). These changes are considered epigenetic because the structure of the genes does not change; rather, what changes are what we might think of as switches that may be turned on or off by environmental stimuli. One fascinating example comes from studies of mother rats and their babies (Francis, Diorio, Liu, & Meaney, 1999; Plotsky & Meaney, 1993; Szyf et al., 2007). Researchers have found genetic markers that distinguish rat mothers who are highly nurturing (e.g., they lick their newborns intensely) from rat mothers who are just the opposite. The baby rats from low-nurturing mothers exhibited high-intensity and erratic responses to stress, in contrast to the babies from high-nurturing mothers. However, when the researchers gave rat infants from low-licking mothers to high-licking mothers, not only did the babies' responses to stress change dramatically, but so did the behaviors of their progeny. To examine how memory of this pattern of stress response might be connected to gene expression, the researchers extracted a gene

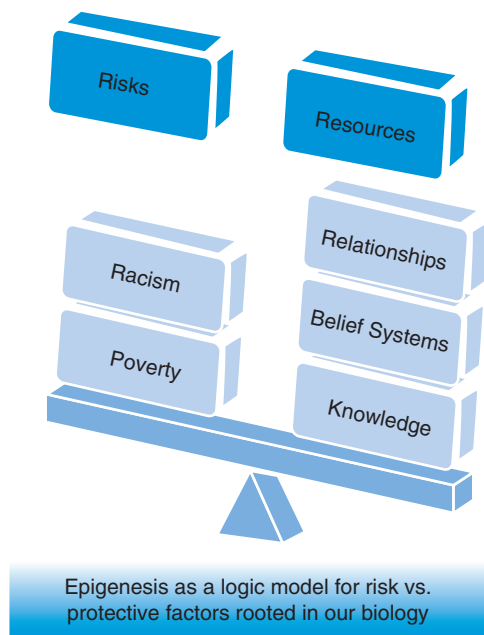


FIGURE 3. *Model of adaptation through risk-resiliency.*

from the hippocampus to examine how its activity compared between low-licked or less nurtured and high-licked or highly nurtured rats. Low-nurtured rats had multiple epigenetic marks that silenced the gene that lowers levels of stress hormone in the blood. As Moshe Szyf says, “The maternal behavior essentially sculpted the genome of their babies. . . . It was a fantastic thing that just a behavior of one subject can change the gene expression in a different subject” (Holt & Paterson, 2007, p. 5).

Although there is a long road to travel to figure out what, if anything, this means for humans, the evidence that biological markers can be turned on or off with short-term stimuli even in humans has been established. For example, researchers at Yale have found that the activation of a gene mutation is associated with the onset of post-traumatic stress disorder (PTSD) *when* there is the experience of extreme stress in *both* childhood and adulthood (Xie et al., 2009). They argue that this suggests that there may be neurobiological buffers to the onset of PTSD when people who have the genetic mutation experience lower levels of trauma, or experience trauma only in childhood or adulthood.

In each of these two examples, epigenetic adaptation makes possible another way of adapting to the environment, beyond what genetic markers would predict.

Adaptation Through Risk-Resiliency Models

I think the fact of epigenesis as a mechanism—at least in animals and humans—represents a logic model for how adaptation is an outgrowth of interactions between risk and protective factors that are rooted in our biology, our physical environments, and our cultural practices. The fact that epigenetic markers on our genes have the capacity to be turned on or off, enhanced or constrained by virtue of experience in the world—experience that arises from cultural practices like nurturing in human families and the invention of medicines and medical protocols—makes a strong argument for the metaphor of the braid of human culture and biology.

The idea of risks and protective factors has a long history in the field of human development, and yet our big debates have to do with what the protective factors and resources are that support resiliency (Spencer et al., 2006). Many of our debates about cultural variation and learning center on these questions. I will try to connect this idea of risk and resiliency with Yetu in the final section of this essay. Figure 3 represents adaptation as the balance between risks and resources as embodied in the underlying logic of epigenetic processes.

Third Orienting Idea: Interdependence Across Levels of Context

Just as biological systems are characterized by interdependence across levels, so relations across levels of context matter for human learning and development. I see here interesting parallels between the idea of interdependence across levels within biological systems and the same idea in our theorizing about ecological systems. In the Bronfenbrenner (1979) model of ecological systems, the microlevels of context (settings where the person routinely participates), the mesolevels (relationships among those settings), the exolevels (settings where significant caregivers of the child routinely participate), and the macrolevels (broader, societal-level beliefs and ideologies, including policies and institutions) are all interdependent and intertwined. Conceptually and methodologically, examining such interdependent contexts is no simple matter. However, the fact that we see such interdependence across levels, both within biological systems and between organisms and their environments, suggests to me that attention to ecological contexts is important if we are to understand and indeed influence human functioning. Understanding and influencing human functioning, I think, is the major task of the education sciences.

Human response to stress illustrates the interdependence across levels of context, from the biological to the environmental (physical and otherwise) to the cultural. The hypothalamic-pituitary-adrenal (HPA) axis represents the body’s system for detecting and responding to stress. Perceptions of stress from our sensory system (e.g., sight, hearing, touch) trigger in the hypothalamus the release of corticotropin from the pituitary gland, which in turn releases glucocorticoids from the adrenal glands, affecting a metabolic and cardiovascular response, resulting in increased availability of energy (McEwen, 1998; Schulkin et al., 1998). This release of cortisol and adrenaline has evolved from our early evolutionary history in what has been termed the *fight-or-flight* response. Figure 4 illustrates how these chemical responses operate, and articulates potential health-related consequences. Many researchers in education-related fields, as well as health fields, study associations between higher cortisol levels and the experience of routine stressors associated with socioeconomic status and racial microaggressions.

There are several interesting, yet disturbing, findings with regard to the experience of stress and a variety of outcomes. First, long-term persistent stress leads to a suppression of anabolic processes, which can lead to diabetes, hypertension, the absence of a menstrual cycle in women of childbearing age, impotence, impaired tissue repair, and obesity (Francis, 2009). Second, there appears to be a physiological mechanism through which the experience of persistent and extreme stress can trigger a routine heightened state of arousal that results in more exaggerated

- Perception of environmental stressors triggers chemical response
- Repeated perceptions of stress increase negative health outcomes
- Dispositions toward such outcomes can be transmitted across generations with biological markers

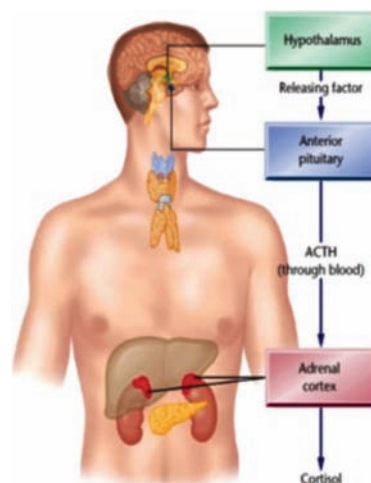


FIGURE 4. *Hypothalamic-pituitary-adrenal (HPA) axis and stress.*

responses to the perception of stress. This involves differential regulation and expression of the glucocorticoid receptor in the brain. It is the intertwining of the biological and the environmental that is both disturbing and a cause for hope.

For me, the takeaway goes something like this: The persistent experience of stress associated with race, ethnicity, and socioeconomic status may have greater and potentially longer term consequences than we imagine, in part because there may well be a physiological consequence of such exposure (note the significantly higher rates of obesity, hypertension, heart disease, diabetes, and cancer in Black and brown populations regardless of socioeconomic status). And such consequences can be intergenerational, both because the sources of stress remain across generations and space and because the epigenetic markers potentially can be transmitted across generations (Adler, Boyce, Chesney, Folkman, & Syme, 1993; Kessler, Mickelson, & Williams, 1999; Krieger, 2005; Williams, 1999). At the same time, we know that there can be multiple buffers or moderators to this politicized exposure to persistent stress. Such buffers can include any combination of the following: belief systems embodied in cultural socialization (e.g., see the research on racial socialization; Bowman & Howard, 1985; Boykin & Toms, 1985; Caughy, O'Campo, Randolph, & Nickerson, 2002; Mandara, 2006; Marshall, 1995); strong social networks that offer resources or social capital that can buffer stressors (Bowman, 1989, 1990; Spencer, Cole, Jones, & Swanson, 1997); structural changes in neighborhood resources, supports for families, comprehensive health care, and so on (Massey & Denton, 1993; McLoyd, 1998; Shonkoff & Phillips, 2000); medical advances such as new epigenetic drugs coming on the market that have been shown to reverse genetic markers (e.g., turn on or off the genetic switch that is associated with particular diseases).

For many of us working in schools in neighborhoods and communities of high poverty, the issue of exposure to and response to stress is no small matter in terms of youths' experiences in schools. Heightened states of arousal upon entering school, patterned responses to perceptions of threat (whether the threat is a physical one from another student or a psychological one from being positioned as less than competent in a classroom),

and health issues that can affect concentration (e.g., lowered sugar levels later in the day for a diabetic student, moving from class to class in a high school for a student who is obese, drowsiness after eating high-sugar and carbohydrate diets in school lunches, being hungry in the morning at school), compounded by severe reductions in opportunities for physical exercise in schools—these are all issues of concern on the ground for educators, issues that are related to quality of educational outcomes for youth disadvantaged by poverty and racism.

The buffers and moderators of these risk exposures of repeated stress are pretty well established and within our powers to address. They are multiple and can come from any of a number of levels of contexts, from government programs to school practices to practices within families and neighborhoods. To address this risk exposure requires an ecological frame and a holistic understanding of how human dispositions, biology, and cultural environments are intertwined.

A Cautionary Tale: Where the Rubber Meets the Road

Throughout this essay I have argued for the importance of investigating the intertwining of biological and cultural influences on human learning and development, but I have deep concerns about how some bodies of research have framed and are currently framing these relationships. There is an emerging body of research examining brain functioning and proposing implications for education, particularly the education and learning of children who live in poverty. This research includes some basic empirical studies in neuroscience and some attempts to synthesize research in brain science explicitly for education. I agree with the cautions expressed by many in the field, including Varma, McCandliss, and Schwartz (2008), about the extrapolation of neuroscience to education:

An important goal of neuroscience is to analyze cognition into elementary functions and to identify neural correlates of those functions. Neuroscientists collect data on the brain areas that are selectively activated during language comprehension, mathematical reasoning, and other cognitive activities. However, knowing the location of an elementary cognitive function tells

us nothing about how to design instruction for teaching that function, just as knowing where the alternator resides in an engine tells us nothing about how to teach driving. Does it really matter for reading education whether phonology is processed by Broca's area, Wernicke's area, the angular gyrus, or the fusiform gyrus? . . . It will be difficult to scale up from data about brain location to explain levels of cognition that educators care about. (p. 142)

I also agree with Varma et al. that neuroscience offers exciting new opportunities to understand human cognition, including the "motivational, cognitive, social, and emotional dimensions of learning as integral" (p. 150).

In this family of studies, those of concern typically have used functional magnetic resonance imaging (fMRI), or neuroimaging, to make comparisons between region brain activation in middle-class and low-income children with regard to language processing, working memory, executive control, and attention, or have used assessments typically used to measure capacity in these areas of cognition. The assessments are generally used as proxies for brain activation of regions associated with these cognitive functions. Overall, the findings represent children from low-income communities as demonstrating lower levels of capacity in these cognitive functions, and the authors extrapolate from the findings that these children are at risk for school failure. Indeed, children living in poverty in the United States are at risk for school failure—not because of working memory or executive control but because of the multiplicity of risk factors they face.

These studies rarely convey cautions about their findings. They rarely question the ecological validity of the assessments or attempt to explain the variation in correlations, even though there may be statistical significance (e.g., What do we know about those subjects who do not fit the pattern that might be useful for understanding resilience?). Studies in this family also do not seem to consider what I take as the most foundational and generative findings from across the myriad fields of neuroscience about the fundamental plasticity of the brain and how we as humans have evolved as adaptive beings. Although interesting work is emerging in cross-cultural studies in these fields, including the field of cultural neuroscience (Chiao, 2010), the studies largely situated in the United States that I think unintentionally continue to reify deficit orientations do not attempt to address issues of cultural variation, either within or across groups, except in static assumptions about the meaning of class status. Consistent with much of the social science research on socioeconomic status and school achievement, school is also positioned as unchanging and static, with little attention to how variation in instruction and the organization of schooling can affect educational outcomes associated with class, ethnicity, and race.

The orientation to understanding human learning and development that I am attempting to capture in this essay inherently calls for interdisciplinary collaborations. The scope and focus of the family of neuroscience studies that concern me here would be greatly advanced by collaborations with researchers in human development, in everyday cognition, in cultural psychology, and in learning in the particular domains. Equally disturbing are attempts to apply findings in neuroscience to practical questions of instruction in a myriad of professional development activities and publications. My recent Google search using the terms *the*

brain and poverty yielded results that I find scary: publications written for a lay audience of teachers, synthesizing and extrapolating recommendations for practice, based on the proposition that poverty has an inherently negative impact on cognitive capacity, emotional self-regulation, and attentional focus. Much of this work does not position the experiences of poverty as posing special risks that children and families must learn to address, but rather as an inevitable set of deficits. Nor does this work typically represent the myriad coping mechanisms that can be found in families, neighborhoods, community institutions, and extended social networks that support resilience in the face of poverty.

I am not Pollyannish or naïve about the experience and risk factors associated with living in poverty. For a good portion of my early life, I lived in public housing on the west and south sides of Chicago. I attended five different elementary schools. But I am deeply cautious about the construction of poverty as inherent deficit that is the meta-narrative in our social and psychological sciences, and in particular about how this meta-narrative has also been associated with race and ethnicity (Lee, 2009).

Integrating the Three Orienting Ideas: An Ecologically and Culturally Focused Framework for Understanding Human Learning and Development as a Way to Understand Difference

In summary, I have identified three big ideas that I think together make for a cohesive argument about the complexity of human learning and development:

1. *The Braid of Human Culture and Human Biology.* Our biology as humans predisposes us toward a set of fundamental dispositions that vary in function and expression across cultural communities (e.g., the salience of human attachments; the intertwining of thinking and feeling; the ways we use patterns that we impose on prior experience to tackle and make sense of new experiences; the importance of perceptions, or our phenomenological disposition).
2. *Adaptation Through Multiple Pathways.* Our cultural variations represent patterns of adaptation to environments (including resisting environments) through multiple pathways. Adaptation through multiple pathways can be found across biological systems, and, as a consequence, understanding models of risk and resilience is important to understanding human learning and development.
3. *Interdependence Across Levels of Context.* Interdependence across levels of context is characteristic of biological systems (from the levels of genes to cells to physiological systems to organisms) in response to and interaction with their environments. This, for me, serves as a powerful warrant for the importance of understanding human functioning in the contexts of our full ecologies, including our physiological systems as one level in ecological contexts.

What I propose is that we think about a human psychological system that involves perceiving, feeling, and thinking as intertwined. These processes are linked because of our biology, but also because of cultural practices that shape our experiences in the world and the meanings we attribute to them. The intertwined

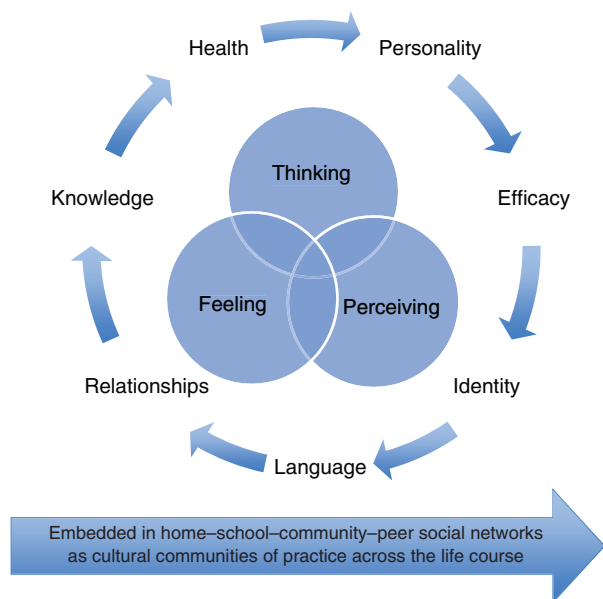


FIGURE 5. *Thinking, feeling, and perceiving as a dynamic psychological system.*

system of perceiving, feeling, and thinking is influenced by our individual personalities; our sense of efficacy in particular contexts; the myriad identities we take on through participation in varied cultural communities; the ways we learn and use language to think, solve problems, and establish relationships; the range of relationships we have with others and what resources those relationships make possible; the knowledge we accrue and construct from our experiences in the world; and the health status of our bodies. This is a complex and dynamic system, as I have tried to represent in Figure 5.

This psychological system is complex because it has many parts and dynamic because there is a self-organizing quality to how the parts intertwine to make for the being of the whole person (Fischer & Bidell, 1998). The sources that influence the elements of this dynamic psychological system come from our participation within and across multiple settings—from home to school to community and peer social networks—and also from our development over time. Figure 5 captures the interdependence among thinking, feeling, and perceiving and what influences their interactions.

The research question is, How do we study this system *as* a system, rather than thinking only about individual parts? And equally important, How do we move from our persistent, prevailing deficit orientation to understanding adaptation and development through multiple pathways?

A culturally and ecologically focused program of research that informs practices on the ground must embody these big ideas of plasticity, adaptation through multiple pathways, and attention to the basic human needs to belong and be competent. Ideally, when working with students we should recruit supports across multiple contexts. In the case of a student like Yetu, for example, educational and other settings that embody these principles will focus attention on how to help him conceptualize and resist that which heightens his vulnerability—his positioning as a Black

male, his poverty, his responsibilities as a father—as well as his resources: his intelligence, his relationships with his parents and his child, his interests, his social networks that offer social capital (attachments, resources). Yetu's settings must be structured to make problem solving explicit and provide supports as he engages in new tasks. They must make explicit the good—personal, social, communal—of the tasks to be learned. They must further help him understand the possibilities in both formal and informal institutions through which he can gain and create access to capital. And attention to his innate possibilities for development can come through multiple pathways, ideally with supports from multiple contexts—some initiated within communities and some initiated through public policy. My hope is that culturally and ecologically focused research, rooted in the kinds of orientations I have described, can help to inform such initiatives. Examples of the roles that public policy can play can be found in Linda Darling-Hammond's (2010) book *The Flat World and Education*. One powerful example of a community-initiated, culturally and ecologically focused intervention to create multiple safety nets is the Harlem Children's Zone (HCZ). The U.S. Department of Education has recently issued a call for proposals based on the HCZ model, called Promise Neighborhoods (<http://www2.ed.gov/programs/promiseneighborhoods/index.html>).

Whitehurst and Croft (2010) recently issued a report from the Brookings Institution criticizing the HCZ as a model for improving educational outcomes. They critique a study by Dobbie and Freyer (2009) that argues for the power of the HCZ model. Whitehurst and Croft, however, provide evidence that some other New York City charter schools score better than HCZ schools, including KIPP. Whitehurst and Croft conclude,

If a schools-only approach works as well or better than a schools plus community approach, this has huge consequences for education policy. It goes to the heart of how public funds should be allocated to enhance educational achievement and reduce socioeconomic disparities. (p. 3)

The cultural and ecological framework I describe would lead researchers to consider whether multiple pathways may contribute to positive outcomes, even if such outcomes are restricted to high-stakes assessments. It may be that both KIPP and HCZ have found ways to develop meaningful personal relationships with students and their families, but that KIPP has augmented a culture of relationship building with pedagogies that make problem solving explicit and public, with guided support, as students engage in the risky behaviors of complex thinking in ways not found at HCZ schools. We do not have process data on instruction in these two schools, nor do we have data on long-term outcomes, such as high school graduation rates and college attendance, which I suspect may not be substantively different for the two schools. And we do not know how such consequential long-term outcomes may be influenced by students' psychosocial development in these two contexts. We do not have data to differentiate how diversity within the Black, brown, and low-income communities served by these two schools affects the needs of and resources available to students, families, and neighborhoods. Overall, if research is indeed to influence public policy, we need data that allow us to examine adaptation and resilience through multiple pathways.

Conclusion

As a research community, we need to produce more studies that examine both risk and resilience and which therefore might better inform policy directions. These studies should move away from static and essentialized conceptions of diversity, acknowledge that variation exists, and explain why it matters and how psychosocial variables and cognition are intertwined. We need studies that examine how people who are Black, brown, and poor experience daily microaggressions (in school, in workplace settings, in neighborhoods) and uncover the range of resources (psychosocial and institutional) that buffer negative impacts. We need studies that examine how everyday cognition, especially among the Black, the brown, and the poor, can be tapped to support academic learning. And we need longitudinal studies that can help us better understand how psychosocial and cognitive development intertwine over time in response to teaching and learning across several settings. But such studies must avoid treating difference as deficit and cultural communities as static. We need longitudinal databases with variables that reflect the possibilities of plasticity and adaptation through multiple pathways as well as the characteristics of settings. When we ask the kinds of rich questions that a cultural and ecological framework leads us to raise, we need to take advantage of the possibilities for examining multilevel contexts over time that are provided by statistical tools such as hierarchical linear modeling, growth curve modeling, and event history analysis.

In sum, to study how people learn and develop over time as learning unfolds in the rich fullness of the ecologies of their lives is the quintessential purpose of a science of learning. These ecologies are not singular, but diverse; not simplistically stable, but evolving. They are constituted by cultural practices that are intergenerational, yet dynamic. Much of what drives these cultural practices is intricately intertwined with the biology of our human species. Systems of physiological, cognitive, and socioemotional development are symbiotically linked. Understanding these complex systems of human activity is the task at hand.

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