Chapter 8

The Importance of Positive Environments on Infant and Early Childhood Neurodevelopment: A Review and Preview of Upcoming, "BE POSITIVE," Research

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Abstract Why do our brains change so much in early life? Why do they continue to develop over time? What are the implications of prolonged neural plasticity for interventions, learning, and childhood well-being? Humans live among ever-changing circumstances and therefore require extensive neurocircuitry supporting abilities to learn, regulate, and respond to information throughout life. Nevertheless, biological plasticity is energetically costly, and so it may be advantageous for infants to take a "best guess" at the type of environment in which they will likely be raised. Will it be dangerous? Will it be filled with unpredictability and a lack of control? Or, will it be comprised of support, certainty, and access to resources? These are important questions: different skills are necessary to succeed in different types of environments. In this chapter, we will consider how brain development unfolds, especially in early life. We will ask, why, from a biological standpoint, early experience impacts developmental trajectories. Next, we will specifically consider effects of the caregiving environment upon neurodevelopment and related implications for individual differences at school age. Gaps in the knowledge base, especially with regard to how such relationships unfold outside of low-risk North American and European homes and school systems, will be highlighted. The reader will learn about a new collaborative Singaporean study, "BE POSITIVE," that aims to address these gaps starting in children 4 months to 4 years. Finally, we will consider ways such research can be applied to shaping interventions and policies aimed at increasing educational success and well-being.

Keywords Neurodevelopment · Adaptation to context · Accelerated development · Sensitive parenting · Cultural expectations · BE POSITIVE

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It's easy to understand why, at the beginning of the school year, teachers send out lists for new school supplies. An old tube of green paint may have been perfect for drawing the plant-life emphasized in last year's biology class, but what happened to the basic blue and yellow necessary for the ocean and sun for this year's geography lesson? The old mathematics text may quickly flip to a discussion of place-value with whole numbers, but this may be a confusing reminder when first learning about decimals. Every year we use the supplies we have for the challenges at hand. Sometimes we can anticipate that these challenges will change, and we try to plan our supply lists accordingly. Often our best guesses are good enough; other times they aren't. In many cases, last year's supplies will work perfectly for this year's needs, but sometimes, despite their fit to last year's class, they may not gel with the current lesson plan. The human brain is not so different. It is shaped in accordance with its experience, often to best meet expectable environmental pressures. If the brain gets cues that the current environment is "positive," it may expect a "positive" future. If environmental cues signal harshness, the brain may similarly adapt accordingly. Importantly, the brain starts guessing about the environment well before school starts. In fact, work suggests such that the environment exerts an influence on brain development as early as the fetal stage (Rifkin-Graboi et al., 2015b).

Environmental influences may have their greatest impact during periods of change. With this in mind, it's important to consider that a great deal of neural development happens within the first few postnatal years (e.g., for reviews see Kolb & Gibb, 2011; Webb, 2001). By the third trimester, most neurons have been born (neurogenesis). Yet, neurogenesis is only the beginning of a neuron's life story. Subsequently, neurons travel, meet others like themselves, get jobs (neural migration and assignment), branch out (axonal and dendritic growth) and make connections (synaptogenesis), either develop their contacts, or let them fade away (pruning), and as part of this process, sometimes, they die of loneliness, while still other times they find ways to relay information quickly (myelination).

Still, despite a plethora of early life change, overall brain development is protracted. For example, substantial change in processes like myelination and pruning are observed into adulthood (Miller et al., 2012; Petanjek et al., 2011). Furthermore, the rate and peak period of change does not just vary from parameter to parameter but also from region to region. In general, areas supporting sensory processes develop earliest and those supporting complex activities like executive control the latest in life (e.g., Gogtay et al., 2004). As such, it's reasonable to think that the degree to which environmental change affects a particular sensory, cognitive, or emotional process may be influenced by whether or not the time of exposure coincides with substantial change in the brain regions that support the specific function. However, because regional development is interlinked, environmental exposures affecting early developing regions may also have secondary effects on higher-order processes.

8.1 Is There a "Benefit" to Prolonged Brain Development?

Why do our brains change so much in infancy, early childhood (Choe et al., 2013; Dean et al., 2015; Giedd et al., 2009; Gilmore et al., 2012; Hu et al., 2013; Uda et al., 2015; Uematsu et al., 2012), and even into adulthood (Miller et al., 2012; Petanjek et al., 2011)? Even in comparison to some of our closest relatives, aspects of human brain development appear especially protracted (Miller et al., 2012). Why, like some other species, aren't we born with more adult-like brains? Why do we have so much capacity to learn? Although, as a species, we are unique in that we have formal schooling, it is highly unlikely that this capacity to learn is a result of schooling. After all, formal schooling did not begin until the 1600s, 263 million of the world's children and youth are, in fact, not in school (UNESCO, 2018), and most of children's lives occur outside of the classroom. Even in Singapore, where there are 193 days of school with about 6 h per day, children are in school only about 13% of the year's hours (or, assuming they get roughly 10 h of sleep per night 23% of their waking time). Instead, our species is likely to have developed a protracted approach to learning and updating knowledge because, throughout our history, we humans have lived among complex social and ever-changing circumstances. We therefore require extensive neurocircuitry supporting abilities to learn, regulate, and respond to new information throughout life (Amici et al., 2008; Holekamp et al., 2015).

Nevertheless, biological plasticity is energetically costly. With this in mind, it may be advantageous for young infants to take a "best guess" at the type of environment in which they are likely be raised (for theory and reviews see e.g., Belsky, 1997; Belsky et al., 1991; Ellis et al., 2011, 2017), or in other words to initiate a "predictive adaptive response"[1] (Bateson et al., 2014; Gluckman et al., 2005). Will the future be dangerous? Will it be one filled with unpredictability and a lack of control? Or, will it be one with much support, certainty, and access to resources? These are important questions and can lead to differences in *which* domain general skills—skills like memory, attention, emotional understanding, regulation, flexibility, and inhibition—are prioritized as well as *when* the development of such skills are prioritized. Knowledge concerning why the development of such skills varies is important to early education for a variety of reasons. As will be discussed in subsequent chapters, domain general skills may be important to mathematical development (see Chap. 13 of this volume); may influence classroom behavior, general academic performance, and behavioral problems (see Chap. 12 of this volume); and may interactively impact language development (see Chap. 15 this volume).

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[1] In the "Predictive Adaptive Response" model, adaptations may be considered to be "immediate" responses to current environmental pressures or "predictive" responses to expectable environmental pressures. In some instances, a given behavior may be advantageous in both the concurrent and future environments.

8.2 Mechanisms

Across a number of fields, there is evidence that signals associated with environmental pressures shape development in a manner that, for much history, may have been advantageous for survival and reproduction. For example, as reviewed by Bateson and colleagues (Bateson et al., 2014), when pregnant women experience environmental adversity in the form of food scarcity, the fetus may begin developing enhanced abilities to search out food and store fat—important physiological and behavioral adaptations if the future is nutritionally uncertain.

Importantly, other aspects of environmental adversity may also be transmitted to offspring. When people encounter challenges that they feel ill-equipped to manage, when they feel marginalized, and/or when they do not feel in control, cortisol, a hormone that releases energy into the body, increases (Dickerson & Kemeny, 2004). Importantly, in addition to providing energy to muscles, cortisol exposure can have widespread other effects, including both chronic and acute effects on neurocircuitry supporting a variety of cognitive and emotional processes (McEwen et al., 2016; Wirth, 2015). While the exact mechanisms for intergenerational transmission are complex and not fully understood, one possibility is that the mother's own physiology influences the fine-tuning of set-points for future susceptibility to environmental influences and accompanying stress physiology, including the production and regulation of cortisol (Anacker et al., 2014; Cameron et al., 2005; O'Donnell & Meaney, 2017). Again, such changes may be adaptive when the current and future environments do, indeed, match the environment signaled by prior cues. If a baby is born into a dangerous environment, there's a pretty good chance that it might be useful to become an adult who reacts intensely to potential threats and be vigilant to change; in contrast, being emotionally regulated, slow to respond, and not easily distracted could have dire consequences.

Likewise, cortisol has also been suggested as a mechanism through which postnatal signals affect brain development. The first way to manage a challenge is with a behavioral response, if that doesn't work the sympathetic nervous system may engage; if that's still not effective, the hypothalamic-pituitary-adrenal (HPA) axis is engaged and releases cortisol (Rifkin-Graboi et al., 2009). Young children lack a number of physical, emotional, and cognitive resources to independently manage many challenges with a behavioral response. In early development, they are dependent upon others to help them with the challenges of everyday daily life (e.g., staying warm, getting food, obtaining an out of reach object of interest, etc.), as well as more exceptional situations (e.g., making new friends, navigating a new place, regulating following injury, etc.). In other words, the younger we are, the more limitations we have to engage in independent behavioral responses to challenge. Indeed, in early infancy, our behavioral options may be mostly constrained to our ability to signal needs. Whether or not these needs are subsequently attended and appropriately responded to is often dependent upon our caregivers. When the needs are not met, physiological responses to challenge may ensue. Over time, chronic increases in cortisol may, in turn, affect the neurophysiological axis that regulates cortisol (i.e., the hypothalamic-pituitary-adrenal (HPA) axis), as well as brain regions influencing HPA regulation, including those important to emotion regulation, memory, and executive functioning.

8.2.1 Sensitive Parenting

"Sensitive" parenting encompasses parental attentiveness as well as responsiveness that is both contextually and temporally appropriate (Ainsworth, 1967). Sensitive parent-child interactions are, in many ways, akin to what is now increasingly called "serve and return" behavior, which refers to a child serving up a signal and a caregiver returning the behavior with a responsive and timely action of his/her own (Shonkoff & Bales, 2011). In addition, inherent to the concept of "sensitivity" is John Bowlby and Mary Ainsworth's idea that the caregiver is a "secure base" from which the child may explore the world. With this in mind, systems assessing sensitive behavior examine the extent to which caregivers appropriately respond to both attachment and exploratory signals and needs (e.g., Moran et al., 2009).

Sensitive parenting may be thought of as a cue that has been historically linked to environmental conditions. Just as physical and social resources are linked to parenting behavior in other species (Hokekamp & Smale, 2015; Perry et al., 2018), across cultures and within Singapore, socioeconomic status is linked to sensitive caregiving (Heng et al., 2018; Mesman et al., 2012; Perry et al., 2018).

In turn, sensitive caregiving and related constructs play a role in young children's exploration of the environment (e.g., Sorce & Emde, 1981) and socioemotional constructs (Dujardin et al., 2015). As discussed in Chap. 11 of this volume, exploratory behavior is itself important to future development and provides opportunities for learning and mastery. In addition, as discussed in this volume's Chap. 12, research finds sensitive caregiving associates with children's emotional understanding. Likewise, sensitive caregiving is often associated with children's stress physiology (Atkinson et al., 2013). Taken together, then, such research suggests that sensitive caregiving is part of one pathway in which likely environmental conditions are signaled to shape brain development.

8.3 Tradeoffs Among Skill Types: Street-Smart Versus Book-Smart

Although it is possible that environmental influences, such as insensitive care, are impeding normative brain development, it is also possible that they are influencing which pathways are prioritized (Frankenhuis et al., 2016; Frankenhuis & de Weerth, 2013). Indeed, the idea that some skills may be prioritized over others fits in with informal ideas about the world's demands, as exemplified by expressions like "he's street-smart not book-smart." While cortisol and insensitive care may be "bad" for the development of regulatory behaviors and physiology, they may be "good" for other skills.

For example, rats that, as pups, were exposed to less licking and grooming (or in other words that had experienced less "rat sensitivity") have been found to show comparatively poor memory for emotionally neutral events both at the cellular (i.e., via long term potentiation) and behavioral level; however, when the rats' cells were first exposed to stress hormones, the rearing-related differences in long-term potentiation patterns normalize and/or reverse. What is more, rats which were exposed to less licking and grooming actually showed better memory for dangerous circumstances than their counterparts (Bagot et al., 2009; Champagne et al., 2008).

Similar findings have been observed in humans. Within human research, abuse is often related to cognitive sequelae, though relations may be complex (Dunn et al., 2016). Reminiscent of the aforementioned rodent findings and the suggestion that, in response to caregiving adversity, the brain prioritizes attending to signals associated with danger, in comparison to non-abused children, when viewing pictures of angry faces, abused children exhibit enhanced neural activity and better/faster identification with incomplete visual information (e.g., Pollak et al., 1997, 2001; Pollak & Sinha, 2002; Shackman et al., 2007, also see Chap. 12 of this volume for a more general discussion of parenting and emotional attentional biases). Similarly, as noted above, children from community samples who were likely exposed to comparatively less sensitive and/or comparatively more frightening early life care exhibit lower levels of cognitive flexibility and selective attention (Bernier et al., 2010; Bernier et al., 2012; Matte-Gagne et al., 2018) and, in early life, coordination between areas of the brain important to modulating emotional reactivity (Rifkin-Graboi et al., 2015a). However, in early life, children exposed to less sensitive care also exhibit greater memory (Rifkin-Graboi et al., 2018), enhanced coordination between areas of the brain important to memory as well as larger volumes of a region supporting memory and stress regulation (i.e., the hippocampus, Rifkin-Graboi et al., 2015a), and, during the preschool years, more fear learning (Tsotsi et al., 2018). As a final example, adolescents who report unpredictable early life experiences show worse performance on inhibition, but better performance in cognitive flexibility specifically when made to think that the current environment is itself unpredictable (Mittal et al., 2015). Thus, many have begun to suggest that whether or not experience is "beneficial" to brain development is partially dependent upon the contexts in which individuals subsequently encounter (e.g., Ellis et al., 2017; Frankenhuis et al., 2016; Frankenhuis & de Weerth, 2013).

8.4 Trade-Offs Among When Skills Prioritized: “Old Before Their Time”

Just as there may be trade-offs between what tasks we prioritize, there are also likely compromises with regard to when we prioritize certain aspects of neurodevelopment. This is conveyed with expressions such as “she had to grow up too quickly” and “old before his time,” which convey that the pace at which development unfolds is related to environmental adversity. Generally, because aging is associated with mortality and cognitive decline, we tend to think of “acceleration” as bad—yet in early life, some forms of accelerated development may go unnoticed and/or be adaptive for survival and reproduction.

Returning to the example of poor nutrition, Gluckman and colleagues (Gluckman et al., 2013; Gluckman & Hanson, 2006) have extensively discussed evidence that reproductive age, at least in females, is sped up among women who experienced antenatal adversity but whose subsequent environments were rich in nutrients. Likewise, Jay Belsky (e.g., Belsky, 1997, 1999, 2000; Belsky et al., 1991) has written at length about similar ideas with regard to pubertal maturation and caregiving adversity. Belsky and colleagues argue that in response to signals of early life adversity, organisms expect later uncertainty and so prioritize developmental pubertal trajectories, as well as emotions, thoughts, and behaviors that may lead to early-and-often approaches to reproduction and accompanying romantic relationship styles. In support of this idea, Belsky and colleagues cite evidence linking early-life insecure attachment parent-child attachment relationships, externalizing behavior, and the onset of menstruation in girls. They propose that while externalizing behaviors may be perceived as “bad” by society, they are part and parcel of a reproductive strategy expected to, in conditions of adversity, maximize the likelihood that ones’ genes are passed on in generations to come.

Inherent in such arguments, then, is also the idea that early adversity may shape brain development. After all, as with other steroid hormones, the axis governing sex steroids originates in the central nervous system (i.e., the hypothalamic-pituitary-gonadal axis). Moreover, increases in sex steroids themselves are responsible for the activation of neurocircuitry supporting certain behaviors at or after puberty, as well as, perhaps, more general neuroanatomical and functional change (Piekarski et al., 2017).

Recently, more work has begun to focus upon “accelerated” neurodevelopment in relation to fear and learning. Though the work varies in its methodologies, it generally points to the idea that offspring prioritize the development of learning strategies necessary for immediate and/or future (predicted) survival. If cues suggest that life is harsh and there is a need for self-reliance, adult learning strategies emerge comparatively early.

For example, as explained by Sullivan and Perry (2015), when rat pups have not been exposed to adverse forms of caregiving, they do not exhibit fear-learning even when they encounter other forms of threat. Why not? As explained above, overwhelming experiences often result in cortisol (or, in rodents, “corticosterone”) increases that can feed back to the amygdala, a brain region important to fear and emotion. In fact, fear learning may be partially dependent upon corticosterone signaling the amygdala (Aubry et al., 2016). However, in rats, the extent to which exposure to frightening stimuli results in corticosterone release follows a developmental progression: first, frightening stimuli may only result in increased corticosterone and so fear learning when the pup has been out of contact with its mother for a rather prolonged period of time; as the pup gets older, frightening stimuli may only result in increased corticosterone and so fear learning when the mother is not present; finally, in even later development, frightening stimuli may result in increased corticosterone and fear learning regardless of whether the mother is present. Sullivan and Perry (2015) explain that the mechanisms behind this maternal buffering may be multifold—including input from regions important to basic functioning (i.e., the brain stem), executive control (i.e., the prefrontal cortex), associative memory (i.e., the hippocampus), and the amygdala itself. When pups experience adverse forms of caregiving, corticosterone is increased in response to frightening stimuli regardless of the mother's presence comparatively earlier in life, and so earlier fear learning may also occur. Such early life fear learning may then further change patterns of activity between the amygdala and regions important to vigilance and control, including the prefrontal cortex.

Relatedly, there is evidence that early life adversity may also speed up processes related to fear regulation and learning in humans. Drawing on knowledge that resting state amygdala-prefrontal connectivity is expected to increase in late childhood and adolescence, Thijssen et al. (2017) wanted to determine whether this normative spurt might occur earlier in development among children (i.e., 6–10 year olds) who had been exposed to insensitive care during preschool. Indeed, they found that increased connectivity associated with age among six-to-ten-year-olds exposed to comparatively low parental sensitivity but not in a group exposed to higher parental sensitivity. In addition, evidence comparing those who have experienced extreme early life adversity also suggests that early life experience influences the pace at which neurocircuitry important to fear regulation and learning develops. For example, Gee et al. (2013) found that children, who have experienced early life institutionalization, demonstrate more "mature" connectivity patterns between the prefrontal cortex and the amygdala, which together regulate fear. That is, unlike Thijssen et al. (2017) who measured brain activity "at rest," Gee et al. (2013) examined connectivity when participants viewed fear faces. They found that children who have never been institutionalized demonstrated positive amygdala-prefrontal cortex co-activation, and teens who have never been institutionalized demonstrated negative amygdala-prefrontal cortex co-activation. However, when viewing fear faces, previously institutionalized children showed more "teenage-like" patterns at earlier stages of life. Furthermore, their work suggests that these patterns may also be beneficial to children as they manage their current environments. Though previously institutionalized children on average showed greater separation anxiety than non-previously institutionalized children, among those who were previously institutionalized, there were fewer symptoms found in those children who showed the more "accelerated" pattern.

Such “acceleration” following early institutional care has also been found with fear *learning*. Silvers and colleagues (Silvers et al., 2016) found that children aged 7–16 who had been institutionalized in early life demonstrated a more adult-like neural activity pattern (i.e., greater co-activation of the prefrontal cortex and the (a) amygdala and (b) hippocampus) while taking part in an aversive learning paradigm than did their never institutionalized counterparts. Moreover, as with the findings concerning fear regulation above, although prior institutionalization was associated with anxiety, among prior institutionalized children, the more advanced neural activation pattern during fear learning predicted a relative decrease in anxiety over time.

Beyond processes important to fear regulation and learning, other forms of learning may also be accelerated. For example, Thomas and colleagues (Thomas et al., 2016) focused on “reversal learning” in mice. They presented mice with buckets that contained a (visually hidden) reward and an associated odor. They then assessed how many trials it took mice to choose, based on the bucket’s odor, the bucket containing the reward. After it was clear that the mice had learned the initial odor-reward pairing, the authors assessed how many trials it took the mice to inhibit old information (i.e., to not dig into the bucket with the old reward odor cue) and act on newly updated information (i.e., to dig into the bucket with the new reward odor cue). When tested as adults, mice showed perseverative errors by continuing to dig into the bucket with the old-reward-odor cue. From an ecological perspective, this may make sense: in the wild adult mice live in stable territories, and so once an association is learned they may require considerable input about the rewarding (or perhaps aversive) quality of an experience before re-evaluating. However, this same strategy may not be useful to juveniles. As they explain, the juvenile period is a transitory time for mice—one in which they are required to explore new areas and assess whether these locations are suitable to be used as a new home territory. Thus, at this stage of development, being open to ever-changing input may actually be advantageous. Indeed, Thomas and colleagues observed that juvenile animals showed fewer perseverative errors in the odor-reward task, if they had not been exposed to early life adversity. If they had experienced early life adversity, juvenile mice displayed the same types of perseverative errors as did adult mice. In other words, mice exposed to early life adversity may display “accelerated” reversal learning.

Likewise, work with human infants suggests that early life adversity may speed up the pace at which learning develops. For example, in a sample of 184 Singaporean infants, Rifkin-Graboi and colleagues (Rifkin-Graboi et al., 2018) found that exposure to less sensitive maternal care at 6 months was associated with better performance during an eye-tracking task designed to assess relational memory, thought to be underpinned by the hippocampus. Likewise, in related Singaporean research, less sensitive care has been associated with larger hippocampal volumes at 6 months and more mature hippocampal microstructure values at 4.5 and 6 years (A. Lee et al., 2019). Similarly, less sensitive care has also been found related to larger hippocampal volume at 10 years in a Canadian sample (Bernier et al., 2019), and less parental nurturance at 4 years of age has been found predictive of larger hippocampal volume among 13–16-year-olds (Rao et al., 2010). However, other work examining the relation between maternal caregiving adversity and hippocampal volume during childhood and adolescence has reported nil (Kok et al., 2015) or opposite effects (Luby et al., 2012; Luby et al., 2016). To truly understand whether associative learning, and relatedly hippocampal development, is accelerated by adversity, it is necessary to repeatedly measure during time points of rapid growth and decline, ideally, within the same sample.

8.5 Mismatch, Culture, and the Local Context

Adults of different cultures can use specific cues to indicate very different things: moving the head side-to-side may signify “yes” to an Indian national but “no” to a Westerner. Saying “that’s quite interesting” signals “keep on talking” to Americans but conveys a substantially different meaning to the British. Nevertheless, if we accept that in early life basic cues concerning adversity and resources—things such as parental sensitivity, (over)protection, nutrition, and the complexity of environmental exposure—may signal likely environmental conditions across a variety of species, it is difficult to imagine that such cues do not also signal historically expectable environmental differences across humans living among different cultures. This is not to say, however, that the accompanying changes in neurodevelopment are equally beneficial for children growing up across all stages of human history, cultures, or contexts.

Gluckman and colleagues have written about the ways in which modern noncommunicable diseases can be traced to a “mismatch” in what constituted adversity throughout most of human history and today’s circumstances. One area that they focus upon concerns differences in nutritional resources. For most of human history, adversity was likely associated with nutritional restriction. However, within many developed countries, fatty calorie-rich food is often the cheapest option. Thus, adaptations associated with early life cortisol signaling (e.g., “be on the lookout for rewards,” “require a lot of calories before satiated,” etc.) may actually lead to increased rates of obesity in the modern environment. Likewise, although adversity may have historically been associated with a need to be hyper-vigilant to environmental cues, in the modern day, classroom-sustained attention is more beneficial than distractibility.

Beyond potential historical clashes, other forms of mismatch may also occur. For example, the fetus may be exposed to heightened cortisol for reasons beyond environmental adversity, such as that occurs when pregnant women eat large quantities of licorice, which has properties that disrupt the inactivation of cortisol (e.g, Räikkönen et al., 2017; Strandberg et al., 2001). Because it’s unlikely that modern day licorice consumption is systematically linked to environmental harshness, the associated cortisol message may not be conveying useful information. As another example, a mismatch can occur when well-meaning caregivers, who are themselves concerned about a child’s academic performance, create overwhelming academic expectations inducing prolonged cortisol exposure within a child. Regardless of its origin, a similar endocrine message may be conveyed: “prioritize skills such as hypervigilance, distractibility, and reactivity to distress.” Unfortunately, research in the West suggests that these skills are in opposition to the ones often required for school success.

As alluded to above, research abroad and within Singapore suggests that working memory, which is supported by sustained attention, predicts a number of academic outcomes including mathematical performance (Lee & Bull, 2016). This skill, along with related aspects of executive functioning- cognitive flexibility as well as emotional and cognitive regulation and error monitoring, is associated with sensitive caregiving and/or secure attachment relationships (Bernier et al., 2010; Bernier et al., 2012; Fearon & Belsky, 2004; Matte-Gagne et al., 2018). Not surprisingly, secure attachment—which is predicted by caregiving sensitivity (De Wolff & van IJzendoorn, 1997) and defined by the child’s ability to flexibly move between the pursuit of exploratory and affectional needs (Main, 2000)—is also associated with teachers’ impressions of preschoolers (reviewed in Sroufe et al., 2005). For example, in Sroufe and colleagues’ longitudinal study, children with histories of secure attachment were less demanding of their teachers, more empathetic, more positively engaged in social interactions with peers, and likely to be treated by their teachers in nurturing and engaged ways but also with age-appropriate expectations for compliance, as indicated by both teacher ratings and observational assessments. In sum, children with secure histories had better relationships with peers and teachers, which could easily then lead to differences in subsequent stress exposure. Moreover, such research suggests that the child’s home histories may be important to their own classroom experience and may also have an impact on the teachers themselves. As will be discussed in Chap. 8 of this volume, classroom demands may influence preschool teacher’s own stress exposure, which may influence the manner in which they engage with children. Both acute and prolonged stress in adults is also found predictive of abilities to regulate and attend (McEwen et al., 2016; Shields et al., 2016).

Indeed, considering the preschool teachers’ experiences, resources, and expectations is an important aspect of determining whether there is a “mismatch” between children’s skills and their concurrent school environment. As discussed in this volumes’ Chap. 11, there are differences in the ways adults teach children, with some focusing more upon instruction (and so imitation) and others upon exploration (and so executive functioning). Some of these differences may arise due to cultural beliefs about learning; others may also be dependent upon whether the adult is able to affectively contingently respond to the changing nature of children’s play. As noted above, executive functioning, a correlate of “positive” early life signals, and presumably required for goal-directed learning, is one of the best predictors of later life success (Israel et al., 2014; Moffitt et al., 2011). However, it remains unclear whether this exact same pattern will hold true for children living in countries where, at least in early life, faithful imitation is more greatly emphasized. For example, we cannot necessarily expect that insensitive caregiving associates with poor school learning across countries emphasizing different pedagogical practices, even if we know that across cultures, adversity associates with insensitivity, and are increasingly certain that insensitivity associates with poor executive functioning (but greater early memory development).

Likewise, pedagogical systems differ with regard to expectations for school readiness. In Finland, children are not taught to read until age seven, and so provided that, by the age of seven, adversity related differences in the pace of memory development normalize, accelerated early life memory capabilities may not be an educational benefit. However, in cultures that expect early literacy by school entry, an inability to easily remember words and their meaning may be met with criticism and relatedly stress, which could ironically lead to higher levels of stress hormones and subsequent difficulties in stress regulation and executive functioning. Thus, it is easy to imagine that "accelerated" development may be more beneficial in some cultures than others.

To determine whether early life adversity helps to create a brain that is more or less in sync with society's expectations and goals, it is important to repeatedly assess early environmental signals and related differences in neurodevelopment in interaction with concurrent societal and pedagogical expectations. For such reasons, the "**BE POSITIVE**" (**B**eginning **E**arly: Singa**P**ore's **O**ngoing **S**tudy starting in **I**nfancy of **T**wenty-first-century skills, **I**ndividual differences, and **V**ariance in the **E**nvironment) study will focus upon environmental quality, memory, and regulatory abilities and will collect data from approximately 1000 families at multiple points in time when underlying brain regions are likely to be exhibiting rapid growth(Rifkin-Graboi et al., 2019). In addition, BE POSITIVE will strive to collect information from child care workers and preschool teachers concerning their expectations regarding age-appropriate knowledge, learning ability, regulatory control, and perspective taking skills.

Because BE POSITIVE includes a variety of potential influences, both universal in nature and culturally specific, we will be better able to understand the degree to which specific environmental influences affect neurodevelopment and when their influences may be most pronounced. Both the type and timing of experience may be especially important (Del Giudice et al., 2011; Ellis et al., 2017; Frankenhuis & de Weerth, 2013).

By collecting data from a variety of different domains (e.g., relational memory, regulatory control, language acquisition), it will be possible to determine how environmental exposures influence trade-offs in which skills to prioritize at a given time point. By repeatedly assessing constructs over time, it will be possible to determine how environmental exposures influence trade-offs with regard to when to prioritize a given skill. In other words, it is not just the timing of exposure, but also the timing of assessment that may influence relations. As with infancy, there are other points in time, marked by changes in adrenal and sex steroids, during which the brain may be especially likely to change (Del Giudice et al., 2009; Piekarski et al., 2017). Some have argued that these stages are also times at which, in accordance with new environmental experience, strategies and skills are re-prioritized. Interestingly, these times often coincide with changes in the educational environment, e.g., 6–8 years of age and during adolescence.

By considering societal expectations, it will be possible to determine the types of pedagogical environments and practices that most readily lead to success among children exposed to more (and less) environmental adversity. BE POSITIVE, then, will augment findings reported in both international and local Singaporean studies of preschool functioning (e.g., see Chaps. 13 and 14 of this volume for a discussion of mathematical and language functioning in the "Singapore Kindergarten Impact Project [SKIP]"). More specifically, BE POSITIVE will help to inform the nature of differences at the start of preschool and provide a framework to better understand why an intervention conducted within one preschool environment may assist some children but negatively impact others.

Finally, by collecting a variety of exposure types, it may also be possible to better examine moderating influences. Ultimately, in any study of environmental exposure, it will be important to consider the role of genetics, prior neuronal functioning, and environmental lability. In addition, it is also important to consider the impact of interventions—both those that are planned and those that naturally occur. For example, Singapore is a multilingual society with most adults reporting fluency in two or more languages. Nevertheless, there is variance in early life bilingual exposure. Considering that bilingual exposure is considered to strengthen executive functioning, Goh et al. (2020) recently examined whether bilingual exposure in Singaporean toddlers could protectively enhance executive functioning, among those at risk for attentional problems. Interestingly, Goh et al. (2020) did find a moderating effect of bilingualism on preschool attentional problems, but this did not appear to be driven by differences in executive functioning. They therefore suggest the need to examine whether bilingually exposed children encounter differential social environments and expectations in early life. Such questions, of course, require the complex assessment of multiple domains and exposures in early life, as will be captured in the BE POSITIVE study.

8.6 How, When, and Should We Intervene?

A main goal of child development research is to improve children's lives. Here, we have presented much research suggesting that early life experiences signaling a "positive" environment are likely to lead to a more "positive" future. Thus, perhaps the key to improve well-being across a number of domains is simply to alter the immediate cues that children receive. Indeed, a number of randomized controlled trials demonstrate the effectiveness of interventions that aim to enhance parenting sensitivity on a diversity of outcomes such as executive functioning, socioemotional behavior, stress physiology, and even language and literacy (Bakermans-Kranenburg et al., 2008a, b; Bernard et al., 2012, 2015a, b, 2017; Dozier et al., 2008, 2011; Grube & Liming, 2018; Klein Velderman et al., 2006a, b; Lewis-Morrarty et al., 2012; Lind et al., 2017; Raby et al., 2018; Velderman et al., 2006). Moreover, in many cases such interventions are found more impactful than those targeted at specific academic skills (Bernard et al., 2017; Lewis-Morrarty et al., 2012; Lind et al., 2017). Intervening with parents may be beneficial for other reasons as well—the effects may transfer to their approach with other children, interventions may be implemented at earlier stages before compounding effects arise, and the interventions may improve the parents' own well-being. Nevertheless, there are potential drawbacks for early interventions with parents, including the cost of implementing individualized parent-child programs. Other solutions, then, which are currently being explored involve creating similar caregiving sensitivity interventions with preschool and primary school teachers (Groeneveld et al., 2011, 2016; Werner et al., 2016, 2018)—however, whether these programs are equally effective is yet to be determined.

Another approach is to focus the intervention at the level of the child, e.g., by trying to boost regulatory skills and decrease distractibility and threat sensitivity. However, there may be some concerns with these strategies as well. Assuming that, in some cases, such "skills" are beneficial in the non-school environment, it is unclear whether improving them will come at a cost outside of the classroom. Likewise, increasing pre-academic knowledge may also be useful—however, if this also increases feelings of helplessness, a lack of belonging, or less time for exploration, it may too come at a cost. Another approach is to acknowledge the usefulness of certain skills and build on them (Frankenhuis & de Weerth, 2013). For example, Ellis and colleagues (Ellis et al., 2017) suggest taking advantage of biases toward negative social information to help focus attention toward key concepts (e.g., before teaching A > B > C therefore A > C, try John is tougher than Ed and Ed is tougher than George, therefore John is tougher than George). As another example, given research suggesting that prior experience with uncertainty leads to better flexibility during times of uncertainty (Mittal et al., 2015), try teaching in a variety of certain and uncertain contexts to give a relative advantage to different types of learners, and so promote feelings of self-esteem.

Likewise, educators can vary learning techniques to account for differences in the pace of development. As reviewed by Piekarski et al. (2017), the manner in which we form memories and learn rules varies with developmental stage. Given that, as reviewed above, developmental stage is not simply equivalent to chronological age and may vary according to prior experience with adversity, it may be important for teachers to consider altering pedagogical styles for different same chronologically aged, but different neurodevelopmentally aged, individuals to enhance learning experiences. Of course, this strategy may too have its drawbacks—including implantation considerations and the fact that harnessing strengths for learning does not necessarily substantially improve quality of life within the home. Indeed, it is likely that a variety of approaches may be needed across different situations, ages, and contexts. How such interventions interact is an important area for future research.

8.7 Summary

Albert Einstein said, "*I never teach my pupils, I only attempt to provide the conditions in which they can learn.*" To understand the conditions that are best suited to helping children learn, it is important to also appreciate why the differences exist and how they enfold over time. In accordance with arguments advanced by Frankenhuis, del Giudice, and Ellis (e.g., Del Giudice et al., 2011; Ellis et al., 2017) and consistent with those offered by Belsky, Gluckman, and others (e.g., Belsky et al., 1991; Gluckman et al., 2005), this chapter has approached the development of differences in cognitive and emotional skills likely needed for school success from an evolutionary standpoint, highlighting research suggesting that cues for environmental harshness (low parental sensitivity, overprotection, poor nutrition) may signal the developing brain to prepare for a difficult future. Whether or not the skills are, in fact, advantageous depends on the future's actual requirements. An educational "mismatch" may occur when the skills valued by teachers are different from those that the children possess. Research such as the upcoming BE POSITIVE study, then, is essential to understanding the ways in which our early and subsequent experiences interact to influence outcomes and may foster greater acceptance of learning differences. It may also help as we determine the best ways to intervene—change the circumstances in which the child develops, change the child, change the pedagogical approach, or some combination of all these.

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