Will the future BE POSITIVE? How Early Life Parenting Signals the Developing “Pre” School Brain

Rifkin-Graboi*, A.; Khng, K. H., Cheung, P., Tsotsi, S., Sun, H., Kwok, F., Yu, Y, Xie[a], H; Yang[a], Y Chen, M., Ng, D.C.C., Hu, P.L., Tan, N.C.

Corresponding Author: Anne Rifkin-Graboi

[a] equal contribution

Prior to kindergarten, our earliest “teachers” and “learning settings” —that is, our parents, caregivers, and homes—provide signals about our environmental conditions. In turn, our brains interpret these species dependent cues as signals indicating the types of environments we will likely face and adapt accordingly. Here we discuss ways in which two such early-life cues—linguistic complexity and sensitive caregiving quality, influence “domain general” neurocircuitry and associated functioning, as well as pre-academic outcomes. We then review methods to assess these functional domains (i.e., temperament and emotional reactivity, emotion regulation, relational memory, exploratory play, and executive functioning) during infancy, toddlerhood, and preschool, and consider how associated differences in neurocognitive function predict later school-age functioning. We conclude by reviewing ways to identify risk in early life and highlighting examples of “upstream” intervention programs targeted at parents, students, and (pre) school teachers. Finally, we suggest the need for contextually relevant research, including plans for a “BE POSITIVE” study, to help bridge the gap between the community, home, and (pre) school environments.

Plasticity and Environmental Signals in the "Pre" Preschool Years

The brain changes an enormous amount within the "pre" school years (Giedd et al., 2009; Lenroot et al., 2007). This early life plasticity may be a product of evolutionary pressures associated with inconsistency in the expectable human environment (Del Giudice, Ellis, & Shirtcliff, 2011). That is, because humans have historically lived in a variety of diverse and ever changing conditions, plasticity allows for "conditional adaptation"—or the ability for an individual brain to develop in accordance with the particular environment it faces (Boyce & Ellis, 2005). However, perhaps because neural organization requires a commitment of biological resources, our brains do not remain equally susceptible to environmental fluctuation across development. Unfortunately, we cannot know exactly what the future holds. In order for the young brain to maximize its chances of developing in a manner consistent with future needs, it may therefore pay special attention to the signals that, over the course of human history, have been most reliably tied to environmental demands (see e.g., Gluckman, Hanson, & Beedle, 2007).

In some cases expectable stimuli is so reliably tied to the environment that when it does not occur within a given period of time the course of development is forever changed. A classic example of this involves work conducted in the 1960's by Hubel & Wiesel on the visual system of cats (e.g., Wiesel & Hubel, 1963). Under normal circumstances, information from both eyes ultimately reaches the left and right visual cortex. When young kittens, born with fully functional eyes, are entirely deprived of light in one eye over their first few months of life, optical radiations from the other eye will take over the innervation of visual cortex, a pattern not seen in adult cats with sensory deprivation. When the kitten grows up it will be forever functionally blind to one visual field, even though its eye is still normal. Keeping in mind conditional adaptation, this makes sense—a complete lack of light for a considerable portion of early development is a pretty good indication that it’s better to repurpose areas of the brain, initially devoted to receiving input from the deprived eye.

Since the time of Hubel and Wiesel, much research has examined what happens when human young are not exposed to such species-expectant stimulation, or stimulation that is likely for all members of a species except in exceptional circumstances, at early stages of development. Sometimes these stages have tight boundaries, and are referred to as *critical periods*. In other cases, research investigates *sensitive* or *optimal periods*, or stages of development when environmental exposure (or lack thereof) is likely to make the greatest impact (see Werker & Tees, 2005). In addition, newer work with humans, using different methodological strategies (e.g., Zeanah et al., 2003), has examined the impact of exposure to other aspects of species expectant stimulation. Additional aspects of species-expectant stimulation are thought to include basic nutrition, basic linguistic stimulation, and access to a caregiver (Nelson, Fox, & Zeanah, 2014).

In addition to *species-expectant* stimulation, *species-dependent* stimulation is also considered important to brain development. For example, while all young humans are expected to receive linguistic input, the type, frequency, and nature (e.g., tonal, click, phonetic) of input may vary according to geographical location and culture. Likewise, while all infants are expected to have basic access to a caregiver, the quality and amount of received care may vary greatly. Next, we review the impact of two species-dependent exposures, linguistic variation and caregiver quality, upon young children’s development.

Species-Dependent Experience

Variation in Linguistic Exposure

In their 2005 review paper Werker and Tees (2005) present ample evidence that human infants preferentially attend to “human speech” sounds, and can distinguish between a wide variety of “human speech” sounds; yet, by 12 months of age the infant brain reorganizes in relation to the specific type of speech encountered. During the first year of life infants demonstrate, via behavior and electrophysiology, that they can differentiate between perceptual properties of speech stimuli, regardless of whether those properties are relevant to their current environment; starting around 12 months, such differentiation is more limited to stimuli that they regularly encounter. Furthermore, Werker and Tees (2005) suggest that while early life exposure to a given language is important, at least some minimal exposure in later development may be necessary for the eventual adult brain to distinguish relevant perceptual aspects. Such work, then, suggest that the infant brain develops in accordance with expectations concerning the future (linguistic) environment, but tweaks its developmental course in relation to subsequently encountered information.

In what follows, we focus on a special example of linguistic variation in the environment, bilingual exposure, and the way it influences development. We highlight bilingualism as it is prevalent around the world, and may continue to increase with globalization and immigration.

Similar to the behavioral and electrophysiological work mentioned above, magnetic resonance studies have noted an impact of bilingualism on brain functioning (Costa & Sebastián-Gallés, 2014). Notably, bilingual and monolingual infants were found to recruit similar language-specific brain areas for language processing: the left superior temporal gyrus for phonetic processing, and the left inferior frontal cortex for meaning retrieval and syntactic and phonological pattern processing (Petitto et al., 2012). However, the two populations differentially responded to Hindi-language contrasts. Ten to twelve month-monolingual infants only activated their left inferior frontal cortex to native contrasts (i.e., English), while their bilingual (but non-Hindi exposed) counterparts demonstrated significant activation to both native and non-native (i.e., Hindi) contrasts. The results indicated that bilingual exposure may increase plasticity of infants’ perception to foreign language exposure and allow linguistic processing across languages. Similar findings have been obtained from comparing monolingual and bilingual children’s semantic processing (Takahashi et al., 2011).

Bilingual exposure also relates to brain structure. Both early and late high-proficient bilinguals demonstrated increased grey matters in left inferior parietal structures (verbal fluency task related area; Mechelli et al., 2004), in left putamen (phonological processing related area; Abutalebi et al., 2013), and in Heschl Gyrus (auditory processing related area; Ressel et al., 2012). In particular, Mohades and colleagues (2012) found two white matter tracts, left inferior occipitofrontal fasciculus and the anterior part of the corpus callosum, changed differently between 8 and 11 years old for simultaneous bilingual, sequential bilingual, and monolingual children. The strongest effect was found in children who start to learn the second language in earlier years (i.e., simultaneous bilinguals), followed by sequential bilinguals and monolingual children.

Interestingly, bilingual exposure may also impact neural circuits important to cognitive control (Grady, Luk, Craik, & Bialystok, 2015; Heidlmayr, Hemforth, Moutier, & Isel, 2015). Likewise, the increased language processing demands in bilingual children have been found to influence other aspects of cognitive and socio-emotional development (Barac, Bialystok, Castro, & Sanchez, 2014; De Houwer, 2015). Considering that children growing up in monolingual versus bilingual environments face different challenges, this may not be surprising. For example, the bilingual environment demands a need for switching between linguistic demands. Likewise, dual language proficiency has been found associated with enhanced executive functioning abilities in children such as set shifting and the ability to inhibit (Bialystok, Craik, & Luk, 2012; but see Paap & Greenberg, 2013; Paap & Sawi, 2014). Specifically, bilingual's linguistic experience (e.g., the length of dual language usage and the frequency of codeswitching) have been found to influence their inhibition control (Bialystok, 2015) and cognitive flexibility (Sun, under review).

Differences in executive control, in turn, may influence theory of mind, an important aspect of social-emotional development in early years (Carlson & Moses, 2001). In particular, some research has shown that bilingual children outperform their monolingual peers in understanding representations and false beliefs (Barac et al., 2014; but see Liu, Wellman, Tardif, & Sabbagh, 2008 for evidence to the contrary). Superior performance of bilingual children on the reality questions in the theory of mind tasks have been specifically linked with their inhibitory processing abilities (Bialystok & Senman, 2004; Kovács & Mehler, 2009). From a sociolinguistic perspective, higher dual language proficiency and longer dual language usage may also facilitate children's other aspects of social emotional development, such as internalizing behavior and externalizing behavior (Han, 2010; Sun et al., 2018).

What might explain bilinguals' enhanced executive functioning? Compared to monolingual children, bilinguals need to notice, sort, parse, and compute the information from two or more parallel language systems, and perhaps cultural schemas. This may thus lead to differences in how children learn. Although both monolingual and bilingual children go through milestones in language development (e.g., babbling, signs of language comprehension, first words, multiple words, short sentences) in the same order and at around the same age ranges (Clark, 2009; De Houwer, 2015), the manner in which they learn to label objects may differ. For example, when shown a known object and an unknown object while listening to an unknown word (Markman & Wachtel, 1988), monolinguals looked longer at the unknown object, guided by a mutual exclusivity heuristic, possibly assuming that one object can only have one label. In contrast, bilingual children looked at both objects for similar durations (Byers-Heinlein, Fennell, & Werker, 2013; Byers-Heinlein & Werker, 2009), potentially suggesting that bilinguals are familiar with the idea that each object could be linked to two labels in two languages, potentially suggesting that bilinguals are familiar with the idea that each object could be linked to two labels in two languages.

Additionally, bilingual children show differences in their learning of number words (e.g., one, two, and three). Unlike learning words for objects, number word learning poses a special learning problem because number words refer to properties of collections of objects, and not to individual objects. Studies from multiple laboratories have shown that although children count early, they take a few years to learn the meaning of the first few number words (*one*, *two*, *three*, and sometimes, four) (e.g., Barner, 2009; Le Corre, Li, Huang, Jia, & Carey, 2016; Le Corre, Van de Walle G Fau - Brannon, Brannon Em Fau - Carey, & Carey, 2006; Wynn, 1990; for a review see Cheung & Ansari, in press). For example, using the Give-A-Number task in which children are asked to give a puppet a certain number of toys, researchers found that, when asked to give Mr. Monkey one banana, a 2-year-old may give a random number of bananas, suggesting that they do not know the meaning of *one*. A few months later, they can generate a set of one object, but they fail on *two* (e.g., giving monkey three or more bananas when asked for *two*). This number-word learning trajectory continues until the number word *three* or *four*. That is, children slowly learn the meanings of *one*, *two*, *three (*and sometimes *four*), one at a time, over the course of 2 to 3 years. The difficulty with learning number words is potentially amplified for bilingual children because number word meanings may be acquired separately in each of their respective languages. Indeed, in a recent study, Wagner and colleagues (2015) found that number word knowledge did not transfer between languages in bilingual children. They found that bilingual children who show knowledge of number words in their dominant number language do not show the same level of understanding in their secondary language. For example, an English-Spanish child who understood the meaning of *two* in English (dominant language) did not necessarily know the meaning of *dos* in Spanish (less dominant language).

In sum, early life variation in language exposure may shape a variety of developmental outcomes prior to children entering school—or even being formally taught. Although in the above section we focused on bilingualism as an example of the way species-dependent environmental variation may impact child development, other aspects of language usage may also influence outcomes. Parental speech (Hart & Risley, 1995), maternal lexical richness and syntactic complexity (Hoff & Naigles, 2002), and the density of sophisticated words uttered in the home (Weizman & Snow, 2001) all predict later outcomes. In the subsequent section, we will address additional aspects of species-dependent experience upon the “pre” school brain.

Variation in the Degree of Sensitive Caregiving

As discussed, there may be sensitive periods during which the brain is especially influenced by bilingual exposure (Werker & Tees, 2005). Likewise, there may be *sensitive periods* during which children are particular influenced by the quality of certain aspects of received caregiving. In this section, we focus on the influence of early life maternal sensitivity upon the developing brain.

Maternal sensitivity refers to degree to which mothers notice and contingently and appropriately respond to their children's cues (Ainsworth, 1967). Similar to the associations observed between maternal protective behavior and rank in nonhuman primates (Holekamp & Smale, 1991), across a variety of human cultures maternal sensitivity is reliably linked to social status (Heng et al., 2018; Mesman, van Ijzendoorn, & Bakermans-Kranenburg, 2012), which is, in turn, associated with stress and/or access to resources (Dickerson & Kemeny, 2004). The degree of maternal sensitivity during early life, then, may be an especially important signal to the young child, concerning his/her family's status, and so the likelihood that he/she will encounter concurrent and future adversity. As with the cat's brain, which can adapt for an environment with or without light, and the infant's brain that can adapt for a monolingual or multilingual environment, the child's brain may also adapt for an optimal or adverse environment, as signaled by early life care. Infants exposed to lower quality care may be expected to show conditional adaptation—or to preferentially develop neurocognitive skills that allow for success in comparatively harsh environments (for discussions concerning conditional adaptation see Boyce & Ellis, 2005; Del Giudice et al., 2011; Ellis, Bianchi, Griskevicius, & Frankenhuis, 2017; Ellis, Boyce, Belsky, Bakermans-Kranenburg, & van Ijzendoorn, 2011), whereas infants exposed to more sensitive care may preferentially develop neurocognitive strategies for more optimal environments.

As with humans, there are forms of rodent behavior associated with limited resources and increased danger. In rodents, variation in these forms of maternal care predicts offspring outcomes that may be adaptive in times of adversity (Beery & Francis, 2011; Cameron et al., 2005), including increased long term potentiation during times of alarm (the cellular process underlying memory) (Bagot et al., 2009), enhanced fear conditioning (“memory for danger”), and increased “freezing” behavior (“reactivity to danger”) (Champagne et al., 2008). However, similar dam behavior limits offspring learning and memory under more environmentally optimal, low-stress conditions (Bagot et al., 2009; Champagne et al., 2008). Likewise, dam behavior impacts offspring endocrine responses to threat, and predicts differential patterns of neuroanatomical growth, especially within circuitry essential to stress regulation (Francis, Champagne, Liu, & Meaney, 1999). In particular, regions important to stress regulation like the hippocampus, amygdala, and prefrontal cortex are impacted by prior experience with stress, including variation in maternal care (McEwen, Nasca, & Gray, 2016). These frontolimbic structures, and their development, are also important to things like autobiographical and relational memory, thinking about the future (Hassabis, Kumaran, & Maguire, 2007), stress and emotion regulation (Frank et al., 2014; Khalili-Mahani, Dedovic, Engert, Pruessner, & Pruessner, 2010), flexibility and perspective taking, and/or the detection of inconsistencies.

Not surprisingly then, some of the current paper’s authors have, in collaboration with other researchers, found associations between sensitive maternal caregiving in human infants and the development of neurocircuitry linked to these abilities in conditionally adaptive ways. For example, some of us have found that young infants exposed to lower levels of maternal sensitivity may prioritize the development of abilities that help them remember danger and act accordingly. That is, infants exposed to insensitive early life caregiving show accelerated hippocampal development (Rifkin-Graboi et al., 2015), greater connectivity between the hippocampus and other memory regions (Rifkin-Graboi et al., 2015), and enhanced memory (Rifkin-Graboi et al., 2018). However, in early infancy we have also observed that connectivity between the hippocampus and the prefrontal cortex is reduced (Rifkin-Graboi et al., 2015). This is important because while the hippocampus is essential to remembering the context in which danger occurs, “fear extinction”—or learning required to shift behavior when conditions have changed—requires both hippocampal and prefrontal cortex involvement (Milad et al., 2007). Indeed, we have found that preschoolers who were exposed to lower levels of maternal sensitivity in infancy are comparatively less likely to reduce their startle response after repeated exposure to a mildly frightening stimulus (Tsotsi et al., 2018). Likewise, others have found that in certain contexts exposure to lower levels of maternal sensitivity in infancy associates with behavioral disorganization (e.g., freezing) during moderate distress in toddlers (Bernier & Meins, 2008).

In addition, others’ research links sensitive caregiving to an infant’s abilities to flexibly balance the competing demands of seeking comfort and engaging in exploration (Main, 2000). This association between sensitive caregiving and balanced exploration and attachment is consistent with the Surplus Resource Theory (Burghardt, 2005), which states that exploratory play can only evolve when there is surplus resources from parents (e.g., safety and provisioning).

Taken together then, when children are exposed to low levels of maternal sensitivity (Atkinson et al., 2013; Blair, Granger, Willoughby, & Kivlighan, 2006; Bosquet Enlow et al., 2014), or other evolutionary signals that their future environment will likely be harsh, uncontrollable, or exclusionary (Dickerson & Kemeny, 2004; Rifkin-Graboi, Borelli, & Bosquest, 2009), a cascade of neurochemical processes may unfold that ultimately influence regions like the hippocampus, amygdala, and prefrontal cortex, and may result in behavior that is adapted to prioritize memory for danger, discount the role of positive information, limit complex exploratory behavior, be sensitive to external threats, and take longer to reverse fear learning. However, as with Bagot et al.’s (2009) rodent work, such adaptation likely comes at a cost. Indeed, a plethora of research also suggests that insensitive care and/or the highly associated construct of insecure attachment negatively impacts aspects of development that may be beneficial in lower stress conditions, including most modern classrooms: attentional focus, flexibility in shifting between rules, the ability to inhibit actions and thoughts, and prosocial socioemotional skills. Likewise, preschool children’s ToM can be predicted from maternal mind-mindedness and attachment security during infancy (Meins et al., 2002), mother’s mental state language (Ruffman, Slade, & Crowe, 2002), and family parenting styles (Pears & Moses, 2003).

Interestingly, not all children may be equally influenced by variance in caregiving quality. Children with of particular temperaments are more susceptible to caregiving behaviors and environmental factors. For instance, infant irritability or reactivity can lead to particularly positive outcomes in response to supportive and enriching experiences, but can also result in negative outcomes in aversive environments (Belsky, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Belsky & Pluess, 2009). In addition, the goodness-of-fit model suggests that the “fit” between child-rearing practices and child temperament predict more favorable child outcomes (Thomas and chess, 1977). For example, fearful children develop positive outcomes when parents use gentle disciplinary strategies, whereas for unfearful children warm and responsive yet firm parenting styles yield best outcomes (Kochanska & Aksan, 2006).

In sum, a large body of research indicates that variation in early life caregiving may be an important experience-dependent influence upon child development. The human brain may treat the degree of exposure to sensitive caregiving as a cue to environmental conditions and adapt accordingly. In addition, although the above section predominantly focuses upon maternal sensitivity, other aspects of early-life parenting may also influence child outcomes including engagement in daily activities and the availability of play materials (Miquelote, Santos, Caçola, Montebelo, & Gabbard, 2012), the amount and type of number talk provided by parents and teachers (e.g., (Gunderson & Levine, 2012; Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2011), home numeracy activities (LeFevre et al., 2009; Skwarchuk, Sowinski, & LeFevre, 2014), and parental responsiveness and stimulating play (Bradley et al, 1989).

"Pre" School Research on Domain General Learning

Given the extent to which domain general neurocognitive development occurs prior to (pre)school, and its impact on subsequent development, it is important to understand ways to identify, in early development, constructs such as temperament/emotional reactivity, emotional regulation, memory, exploratory play, executive control and the related concept of Theory of Mind. Neural regions supporting these constructs can be found in Table 1.

Temperament and Emotion Reactivity

In general, temperament refers to early emerging dispositions, in reactivity, affectivity, attention and self-regulation (Shiner et al., 2012). Although temperament may impact the degree to which the environment influences children's outcomes, temperament itself is shaped by the interactions among genetic and environmental factors across time. Genetic make-up contributes to about half of individual differences in temperament (Caspi, Roberts, & Shiner, 2004), though sociocultural influences may also play a role (Kagan et al., 1994; Lewis, Ramsay, & Kawakami, 1993; Rubin et al., 2006).

Temperament shows stability and continuity over time and consistency across situations (Rothbart & Bates, 2006), but there are also significant changes during development (Roberts & DelVecchio, 2000). These changes in temperament are often measured through direct observations or parental questionnaires in early childhood. For example, Jerome Kagan and his colleagues created a behavioral battery to observe infant’s reactivity in laboratories (Kagan, Snidman, & Arcus, 1998). During the assessment, four-month-old infants are presented with a series of novel stimuli, such as mobile toys and unfamiliar voices. Infants who are motorically aroused and distressed to the novel stimuli are categorized as high reactive. Infants who display minimal motor activity and distress are categorized as low reactive. In addition to behavioral observation, parental questionnaires are often administered to learn about children’s temperament across situations (Gartstein & Rothbart, 2003).

Temperament measured in early childhood predicts later child outcomes. For instance, infants who were classified as highly reactive were more likely to become inhibited toddlers who showed more fearful reactions when facing unfamiliar stimuli, compared to infants classified as low reactive (Kagan et al., 1998). Furthermore, temperament significantly predicts children’s later school adjustment and academic achievements (Al-Hendawi, 2013). Particularly, school adjustment is positively correlated with self-regulation, but negatively correlated with negative affectivity. Activity level (i.e., physical energy) predicts children’s academic achievements, especially reading competencies.

Emotion Regulation

Emotion regulation refers to processes involved in the modulation of emotional arousal and reactivity in order to adapt to a given environment and accomplish one’s goals (Cole, Martin, & Dennis, 2004; Thompson, 1994). As noted directly above, variations in emotion regulation may be attributed to inherent child attributes (e.g. temperament), but may also be influenced by the environment (Eisenberg, Spinrad, & Eggum, 2010). For example, sensitive contingent caregiving is associated with better regulation of anger, frustration (Conway et al., 2014; Feldman, Dollberg, & Nadam, 2011), and fear (Tsotsi et al., 2018) at around age three.

In addition, the degree to which emotion regulation relies on internal versus external factors also depends on developmental stage. In infancy, emotion regulation is often determined by caregiver-led processes (e.g., physical touch) (Cassidy, 1994; Spinrad & Stifter, 2002), along with some self-soothing behaviors, such as finger sucking (Braungart-Rieker, Garwood, Powers, & Wang, 2001). With age, children’s own attentional, memory, and executive functioning abilities begin to play a role (Eisenberg et al., 2010). Increasingly, children become able to inhibit their automated responses, behave intentionally and even plan their responses (Diamond, 2002). Furthermore, across development the growing necessity for socialization, including peer and adult expectations, drives children to respond in more sophisticated and socially appropriate manners (Bridgett, Burt, Edwards, & Deater-Deckard, 2015). Still, even at school age, the presence of an important caregiver may be important to neural functioning during an emotional regulation task (Gee et al., 2014). In addition, across development the growing necessity for socialization, including peer and adult expectations, drives children to respond in more sophisticated and socially appropriate ways. Still, even at school age, the presence of an important caregiver may be influential to neural functioning during an emotional regulation task.

In young children emotion regulation is usually measured through observational methods (that encompass coding of behavioural responses to given stimuli or situations), physiological changes (e.g. heart rate variability) or reports by caregivers or teachers. The Still-Face Paradigm (Tronick, Als, Adamson, Wise, & Brazelton, 1978) is one example of an observational method for infants who undergo a face-to-face interaction with their parent in three steps, i.e. a baseline interaction as usual, a “still-face” episode, wherein the parent becomes expressionless, and the return to usual interaction. Likewise, the Transparent Box task (Goldsmith, Reilly, Lemery, Longley, & Prescott, 1999) is designed to elicit frustration and calls for frustration regulation in preschoolers; it involves locking a desirable toy in a transparent box, handing the wrong set of keys to the child and asking them to open it to play with the toy. Children’s expressed frustration and anger is then assessed based on their bodily movements, facial expressions, and vocalizations. Such paradigms can also be used to collect physiological data (e.g., Conradt & Ablow, 2010; Moore et al., 2009)

Differences in emotion regulation predicts a variety of social outcomes including peer relationships (Raver, Blackburn, Bancroft, & Torp, 1999; Séguin & MacDonald, 2016) internalizing problems (Blair, Denham, Kochanoff, & Whipple, 2004; Silk, Shaw, Forbes, Lane, & Kovacs, 2006), and externalizing problems (Eisenberg et al., 2001). In the school setting efficient emotion regulation skills were related to respect towards others (Miller et al., 2006), better compliance to rules (Gilliom, Shaw, Beck, Schonberg, & Lukon, 2002), and adjustment in the classroom (i.e., positive interactions with teachers and peers, participation in structured activities, language and numeracy skills; Shields et al., 2001). In addition, emotion regulation difficulties may hinder children’s concentration on a given task in the classroom, further obstructing their learning (Howse, Calkins, Keane, & Shelton, 2003).

Relational Memory

Relational memory is an aspect of explicit or “conscious” memory and is considered essential to binding facts together—an obvious component of learning, but also important to autobiographical memory and engaging in future thinking or prediction (Richmond & Pan, 2013). As such, relational memory is important to building representations of the world, which are themselves essential to both cognitive and socioemotional schemas that guide cognition and emotion. As discussed above, relational memory may be influenced by parenting behavior, and, perhaps due to the hippocampus’s richness in steroid receptors, other forms of endocrine variation, including obesity (Khan et al., 2015).

Relational memory may begin to emerge by six to nine months of age, and in infancy is often investigated via eye tracking paradigms (Chong, Richmond, Wong, Qiu, & Rifkin-Graboi, 2015; but seeGomez & Edgin, 2016; Richmond & Nelson, 2009; Richmond & Power, 2014). For example, during an encoding phase, infants are presented with scene-object pairs. Then, during a retrieval phase the same scenes are shown, but with a multitude of objects superimposed upon them. The degree to which the infant looks at the object that was previously paired with the scene (as compared to objects that are familiar but not correctly paired) is taken as evidence of relational memory. At later stages of development tests of relational memory may also assess other aspects of behavior including accuracy (Pathman & Ghetti, 2016). Interestingly, aspects of relational memory may differ in their rate of development—with “item-space” binding reaching adult levels by age 9, item-time by age 11, but item-item not fully developed until adulthood (Lee, Wendelken, Bunge, & Ghetti, 2016).

Exploratory play

One of the first ways infants and young children explore and learn about the world is through play (Bruner, Jolly, & Sylva, 1976; Groos, 1901; Piaget, 1962). From as young as 5 months of age, infants start to manipulate novel objects in a way different from familiar objects, and they gather information in the process (Ruff, Saltarelli, Capozzoli, & Dubiner, 1992). This type of “exploratory play” has a pivotal role in understanding how early environment affects the development of brain and behavior.

Developmental research has shown that play in general supports the acquisition of cognitive, social, and motor skills in human children (Bjorklund & Brown, 1998; Hirsh-Pasek, Golinkoff, & Eyer, 2004; Hutt & Bhavnani, 1972; Pellegrini & Smith, 1998; Singer, Golinkoff, & Hirsh-Pasek, 2006; Youngblade & Dunn, 1995). Exploratory play, in particular, has cascading effects on children's learning about the physical and social world (Libertus & Needham, 2010; Rakison & Krogh, 2012). Infants’ exploratory play helps develop cognitive skills such as the understanding of goal-directed actions (Gerson & Woodward, 2014; Sommerville, Woodward, & Needham, 2005), causal reasoning (Rakison & Krogh, 2012), mental rotation (Schwarzer, Freitag, & Schum, 2013), and vocabulary learning (Ruddy & Bornstein, 1982). For toddlers and preschoolers, exploratory play has been shown to facilitate spatial cognition (Oudgenoeg-Paz, Leseman, & Volman, 2015), hypothesis testing (Legare, 2014), and forming higher-order generalizations (Sim & Xu, 2017). Longitudinal studies have further identified long-term consequences of early exploratory play. For example, Yarrow, Klein, Lomonaco, and Morgan (1975) has shown that duration of exploratory play at 6 months predicts Binet IQ at 3.5 years. Similarly, Muentener, Herrig, and Schulz (2018) has shown that the efficiency of infants’ exploratory play predicts vocabulary size and IQ at age 3.

Executive Function

Likened to an air traffic control system, executive functions (EFs) support adaptive, goal-directed behaviors with its primary groups of functions: working memory (monitoring, manipulating and updating information), inhibition (resisting inappropriate prepotent responses/impulses or interference from irrelevant information), and shifting (mental set shifting; also termed switching or cognitive flexibility) (Diamond, 2013; Miyake et al., 2000). Executive functions are essential for self-regulating thoughts, emotions, and actions, and underlie a broad range of skills and behaviors on all levels ranging from acquiring a motor schema like cycling, staying focused and engaged in a task, resisting temptations and distractions, regulating stress and negative affect, sustained play and interpersonal relations, resilience, to physical and mental well-being (Diamond, 2013). Self-regulation is often also studied as self-control and other related constructs (Moffitt et al., 2011) and has been regarded “a key to success in life” (Baumeister, Leith, Muraven, & Bratslavsky, 2002, p.117). As previously discussed, EF associates with differential maternal care, stress hormone exposure, and bilingualism.

Early self-regulation has been found to predict later outcomes such as achievement, health and economic standing, and quality of life—even more so than IQ or socioeconomic status (e.g., Moffitt et al., 2011). Executive functions have been found to be more important for school readiness than IQ or entry-level reading or math, and to predict success throughout school (preschool through university) in diverse areas (see e.g., Diamond & Ling, 2016), including social functioning (e.g., Diamantopoulou, Rydell, Thorell, & Bohlin, 2007) and moral development (Kochanska, Murray, & Coy, 1997).

Tests of EF typically separately measure working memory, inhibition and shifting. Tasks for adults and older children are often computerized; administrations for very young children may involve the use of concrete materials (such as cards) to present age-appropriate stimuli (e.g., pictures of animals), and tend to be shorter and less complex. While a task for a three-year-old may look slightly different from that administered to a twenty-year-old, much research has gone into creating paradigmatic tasks/batteries that can measure EF constructs across most of the lifespan. For instance, the NIH Toolbox (NIHTB) provides versions of similar EF tasks appropriate for individuals from 3 - 85 years of age (Weintraub et al., 2013). However, while tasks assessing separate EF components can be administered to children as young as 2 to 3 years of age, developmental studies have suggested that the separation among EF components are less distinct in early childhood (see Lee, Bull, & Ho, 2013).

Tasks for children below the age of three tend to look quite different from adult versions, and may reflect combined EF rather than its respective components. For instance, in the A-not-B/delayed-response task, an infant watches a desired object being hidden in one of two places (left/right) and is encouraged to find reach for the hidden object after a few seconds' delay. In order to find the object, the infant needs to engage his/her working memory to hold and update information on the most recent object location, and resist proactive interference from irrelevant location information from previous trials. As the infant is rewarded for each correct reach (by obtaining the desired object), the action of reaching to that particular location is reinforced, increasing the prepotency of the reaching response to that location. When the hiding location is switched, the infant must then inhibit the prepotent tendency to reach to the previously rewarded location and respond according to the most updated mental representation. Infants show improvement on this task between 6 to 12 months, reflecting development in EF (Diamond, 2002). At even younger ages (e.g., 3.5 months), looking behaviors (e.g. looking duration and visual anticipation) measured via eye tracking (Haith, Wass, & Adler, 1997; Posner, Rothbart, & Thomas-Thrapp, 1997; Quan et al., 2017) and reaction time have been taken to reflect attentional capabilities and efficiency of information processing, and found to correlate with regulatory abilities (Diaz & Bell, 2011) and later speed of processing and IQ (age 4) (Dougherty & Haith, 1997).

Theory of Mind

Theory of Mind (ToM) refers to children's understanding of their own and others' minds, and is a foundational social cognitive skill that draws interest of researchers from different disciplines (Carlson, Koenig, & Harms, 2013). It is often linked to executive functioning as it requires "switching" perspectives and holding multiple thoughts in mind (Carlson & Moses, 2001).

For most children, ToM develops in a stable, predictable sequence (Wellman, Cross, & Watson, 2001). Before their second birthday, infants typically understand that people have different desires (Repacholi & Gopnik, 1997), and their actions are goal-directed (Woodward, 2009). However, it is not until preschool years when children show adult-like understandings of other's beliefs. For example, children below 3 years of age typically have difficulty understanding that people can believe something that is false ("false belief"), such as Sally believing a marble to be in its original location even though in reality it has been moved unbeknownst to her (Wimmer & Perner, 1983). Newer methods using looking time measurements have revealed early forms of false belief reasoning even in infancy (Baillargeon, Scott, & He, 2010), though whether infants’ looking time truly reflect an understanding of ToM remains a controversial topic (Dörrenberg, Rakoczy, & Liszkowski, 2018). To date, the Theory of Mind Scale (Wellman & Liu, 2004) remains the standard measurement for ToM development in verbal children.

As noted above, ToM is influenced by variation in language exposure and parenting behavior. In addition, there are close relations between the development of ToM and language (Milligan, Astington, & Dack, 2007), executive function (Carlson & Moses, 2001), and pretend play (Taylor & Carlson, 1997). ToM development also has long-term implications for children’s cognitive and social functioning, such as social competence, peer acceptance, and early success in school (Astington & Pelletier, 1998; Dunn & Cutting, 1999).

(Insert Table 1 about here)

Interventional Approaches during the “Pre” School Years

There are multiple reasons to focus on prevention and intervention prior to (pre) school age. As discussed above, the early years may constitute sensitive periods for a variety of experience expectant and dependent exposures. These risks may have consequences: demographic risk profiles have been found predictive of academic trajectories from first grade onwards, in contrast to IQ, which is only predictive amongst low risk students (Gutman, Sameroff, & Cole, 2003). Moreover, early intervention, early education, and early identification enhances individuals’ quality of life sooner, rather than later. In addition, from a learner's perspective, interventions that occur before school age alleviate the potential for social stigma that, rightly or wrongly, may accompany being part of school-based learning support. Likewise, the benefits of both intervening prior to (pre)school and educating (pre) school teachers about the strengths and challenges associated with varying environmental exposures may also lead to less frustrating experiences for children, families, and educators.

In the next section, we discuss early screening, as well as early intervention programs targeted at young learners and their families. Here, we give examples of interventions focused on changing general behavior (rather than altering very specific discrete behaviors) and enhancing regulation, and present a brief discussion of an alternative intervention approach for (pre)school teachers—suggesting the benefits of working with, rather than aiming to change, pre-existing child profiles. We have chosen to highlight such "upstream" and/or global approaches because in the real world, children often encounter a diversity of risk factors (e.g., low birth weight, antenatal exposure to neurotoxic substances, health conditions, developmental delay/disabilities, poverty, low parent education, ineffective parenting, child maltreatment, family dysfunction) which may collectively impact their lives (Doll & Lyon, 1998) in complex and intertwined ways (Furstenberg, Cook, Eccles, Elder, & Sameroff, 1999).

Early Screening

Developmental screening is a brief, easy-to-complete formal test of young children's development (Bricker, Macy, Squires, & Marks, 2013,). Developmental screening has been found to be reliable and valid in identifying young children who are or at risk for developmental delays and disabilities. Research shows that the accuracy of developmental screening can be significantly enhanced by using a formal tool such as the Ages & Stages Questionnaires (ASQ, Squires & Bricker, 2009) instead of the traditional way of surveillance check-ups (Rice et al., 2014). Besides using a reliable and valid tool, other practices such as involving the caregivers in the assessment and collaborations across multiple disciplines were also found effective in developmental screening (Bricker et al., 2013).

In addition, a better understanding of the type of early developing behaviors discussed above may also enhance early detection. Executive function deficits are often associated with neurodevelopmental disorders, such as Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorders (ASD), and learning disorders, such as in language and mathematics (Gathercole, Alloway, Willis, & Adams, 2006; Geary, 2003). As another example, exploratory play both predicts and serves as a diagnosis tool for developmental disorders. The clinical diagnosis of ASD and ADHD is partly based on the judgment that children engage in atypical exploratory play (e.g., restricted/repetitive play in ASD, and distracted/disorganized play in ADHD; American Psychiatric Association, 2013). Differences in exploratory play have also been found between typically developing infants and infants at risk of Downs Syndrome (de Campos, da Costa, Savelsbergh, & Rocha, 2013; Loveland, 1987), at risk of ASD (Kaur, Srinivasan, & Bhat, 2015; Koterba, Leezenbaum, & Iverson, 2014), or born prematurely (Sigman, 1976; Zuccarini et al., 2016). As a final example, ToM deficits (Baron-Cohen, Leslie, & Frith, 1985) are often present in those with ASD, and deviations from typical early language, nonverbal development, and early social communication skill trajectories may predict ASD (Zwaigenbaum et al., 2015). Thus, as with some other special needs, although ASD is often not diagnosed until 3 to 4 years old, early markers can be identified between 1 and 2 years, and such early detection of risk is increasingly considered important (Zwaigenbaum et al., 2015).

Caregiver Interventions

Caregiver Sensitivity

As reviewed above, sensitive caregiving and the closely related construct of security in infant attachment relationships (De Wolff & van Ijzendoorn, 1997), are predictive of a host of developmental sequelae including externalizing behavior and friendship formation (Groh, Fearon, IJzendoorn, Bakermans-Kranenburg, & Roisman, 2017), attention (Fearon & Belsky, 2004), executive functioning (Bernier, Carlson, Deschenes, & Matte-Gagne, 2012; Matte-Gagne, Bernier, Sirois, Lalonde, & Hertz, 2018), language development (Paavola, Kemppinen, Kumpulainen, Moilanen, & Ebeling, 2006), academic achievement (Dindo et al., 2017; Moss & St-Laurent, 2001), and fear learning (Tsotsi et al., 2018). One evidence based approach to enhancing sensitive caregiving is the Video Intervention to Promote Positive Parenting and Sensitive Discipline (VIPP-SD) (Juffer, Bakermans-Kranenburg, & Van Ijzendoorn, 2018). The VIPP was originally developed for parents but has now been expanded to reach home- and centre-based teachers (Groeneveld, Vermeer, van IJzendoorn, & Linting, 2016; Werner, Vermeer, Linting, & van IJzendoorn, 2018). This approach relies on individualized feedback, as meta-analytic findings indicate personalized feedback is an important predictor of effectively enhancing sensitivity in parents (Bakermans-Kranenburg, van IJzendoorn, & Juffer, 2003) and preschool teachers (Werner, Linting, Vermeer, & van IJzendoorn, 2016). To date, these intervention programs target caregivers of children aged 6 months to roughly 5 years, though their feasibility with older age ranges is being investigated. Randomized clinical trials find the VIPP effective at enhancing sensitive caregiving, and/or improving child outcomes—in some cases especially in children who are at risk for externalizing problems and/or are more genetically susceptible to environmental variation (Bakermans-Kranenburg, Van Ijzendoorn, Pijlman, Mesman, & Juffer, 2008; Klein Velderman, Bakermans-Kranenburg, Juffer, & van, 2006; Klein Velderman, Bakermans-Kranenburg, Juffer, Van, et al., 2006; Van Zeijl et al., 2006; Velderman et al., 2006). Unlike other forms of caregiving interventions, which specifically target “downstream” behavior such as increasing parental word count, language complexity, or instructional support, the VIPP aims to increase caregivers awareness of a specific child’s needs and promote appropriate and timely responses. Interveners highlight children’s signals for both attachment and exploration, frame behavior within a developmental context, and point out the reciprocal nature of caregiver-child interactions. Importantly, drawing on results from a very similar individualized feedback intervention program, the Attachment and Biobehavioral Catch Up (ABC) program, interventions aimed at enhancing caregiving sensitivity are as or even more effective than are parenting interventions specifically designed to enhance children’s (pre) academic outcomes in the domains of EF (Lewis-Morrarty, Dozier, Bernard, Terracciano, & Moore, 2012), stress physiology (Dozier, Peloso, Lewis, Laurenceau, & Levine, 2008), and language development (Bernard, Lee, & Dozier, 2017). Thus, although programs designed to enhance global sensitivity, such as the VIPP-SD and ABC, require an investment in training and individualized interactions, their ‘bang for buck” may be substantial as they have the potential to increase well-being across a variety of people (e.g., children and their caregivers) as well as impacting other domains including children’s executive functioning and regulation.

Mindfulness

Closely related to caregiver sensitivity is caregiver mindfulness. Mindfulness refers to a quality of attention: fully focused on the whole spectrum of the present moment’s experience, in an open, curious, and non-judgmental manner (Kabat-Zinn, 2003). An accepting and non-reactive awareness contributes to cognitive, emotional, and behavioral regulation by enabling one to respond reflectively rather than react reflexively (see, e.g., Chiesa, Calati, & Serretti, 2011), and facilitates self- and other-compassion.

Parents with higher levels of mindfulness were found to be more attuned and responsive to their child’s needs, mediated by lower levels of parenting stress (Campbell, Thoburn, & Leonard, 2017). Maternal mindfulness was positively associated with positive mother-child relationships (e.g., higher levels of parent reported abilities to notice children’s signals and provide comfort, involvement, and parenting confidence; lower discipline practice and relational frustration), resulting in better child outcomes (lower emotional symptoms, conduct problems, hyperactivity, and peer problems; higher prosocial behavior) (Siu, Ma, & Chui, 2016). An individual’s level of mindfulness (intrapersonal mindfulness) can be enhanced with mindfulness-based practices (also known as mindful attention training), comprising predominantly sensorial based, mind-body integrative practices and can include explicit compassionate practices such as sending kind thoughts to self and others. Broadly, mindfulness and various mindfulness-based programs/interventions have demonstrated benefits to attentional, emotional, and behavioral regulation, from enhanced cognitive abilities (e.g., sustained attention and executive functions), increased empathy, self-compassion and quality of life, to reduced negative psychological symptoms (e.g., anxiety, depression, rumination, anger, and distress) (e.g., Chiesa et al., 2011; Keng, Smoski, & Robins, 2011; Meiklejohn et al., 2012).

In addition to parents’ focusing upon their own intrapersonal mindfulness (i.e., parent mindfulness), they may also facilitate their children’s growth through increasing interpersonal mindfulness in the context of parenting (i.e., mindful parenting). Mindful parenting involves dimensions such as listening with full attention to the child, emotional awareness and non-judgmental acceptance of self and child, self-regulation in parenting, and compassion for self and child (Duncan, Coatsworth, & Greenberg, 2009). Across children of different age groups (3 to 17 years), higher parent mindfulness was consistently related to lower child internalizing and externalizing problems, through higher mindful parenting and lower negative parenting practices (Parent, McKee, Rough, & Forehand, 2016). Mindful parenting was also negatively correlated with anxiety and depressive symptoms in parents, and positively associated with child well-being through more secure attachment (Medeiros, Gouveia, Canavarro, & Moreira, 2016). Although research on mindful parenting interventions is still nascent, some evidence suggest positive intrapersonal changes, for example in parent mindfulness and wellbeing (e.g., self-compassion, stress, negative mood, and anger management), and interpersonal changes in parenting (e.g., parent-child interactions, discipline practices, empathic concern, and family functioning) (see Benn, Akiva, Arel, & Roeser, 2012; Coatsworth et al., 2015; Van der Oord, Bögels, & Peijnenburg, 2012). In children with ASD and other developmental disabilities, mindful parenting intervention shows promise for improving child outcomes such as decreased aggression, noncompliance, self-injury and increased social skills (Singh et al., 2006; Singh et al., 2007).

Programs to Directly Enhance Children’s Regulatory Abilities

Child-focused interventions reported to benefit regulation and executive control include computerized cognitive training, mindfulness, aerobics, resistance training, games, martial arts, yoga, theater, and specific school curricula such as the Tools of the Mind (Tools; Bodrova & Leong, 2007), a curriculum for preschool and kindergarten. In general, activities/training have more potential to improve EF the more they provide opportunities to engage EFs in challenging and diverse ways, with longer and sustained/consistent practice, and in individuals with poorer starting states (i.e., poor EF, related to variables such as SES, ADHD, or otherwise). Other factors such as having a facilitator with strong commitment and conviction, and whether the activity brings other benefits that in turn enhances EF (e.g., stress reduction, physical health or social well-being) may also moderate effects (see Diamond & Ling, 2016, for an integrative review).

A class of interventions give children repeated practice on tasks requiring the engagement of EFs, typically based on paradigms used for assessing EFs (e.g., a running-span working-memory task), computerized and programmed to be game-like and child-friendly. Examples of such direct, computerized cognitive training include sustained attention, inhibitory control and conflict resolution, and especially working memory (e.g., Ang, Lee, Cheam, Poon, & Koh, 2015; Rueda, Checa, & Cómbita, 2012). Some studies have found improvements in the target EF but vary in terms of near transfer to untrained tasks of the same EF function (e.g., Ang et al., 2015; Rueda et al., 2012); others have found far transfer to competencies not directly trained, such as fluid intelligence (Jaeggi, Buschkuehl, Jonides, & Shah, 2011) and mathematical performance (Bergman-Nutley & Klingberg, 2014). As with most broad classes of interventions, training parameters and success vary across studies and may depend on various moderating factors (see Diamond

& Ling, 2016; Jaeggi, Buschkuehl, Jonides, & Shah, 2012; Klingberg, 2010; Shipstead, Hicks, & Engle, 2012).

In addition, there are also interventions specifically concerned with regulating emotional experience, which typically focus on building resilience. This practice likely stems from evidence indicating that the adaptive self-regulation of emotions is predictive of resilience, especially among children who have been exposed to chronic adversity (Bonanno & Diminich, 2013). As emotion regulation contributes greatly to children's risk for further developing psychopathology or other maladaptive outcomes, boosting emotion regulation may be especially important. Emotion regulation involves modulating responses that transpire at multiple levels (e.g., physiological, behavioural). Therefore, intervention programs aim to enhance emotion regulation on the physiological, affective, cognitive and interpersonal levels (Rosen et al., 2018), and may act via changing children's initial reactions to emotional stimuli and/or modulating these initial responses (Koole, van Dillen, & Sheppes, 2011).

"Managing Frustration for Children" is a 12-week training for 5-8-year-olds (Rosen et al., 2018) that addresses all of these levels through psychoeducation on spontaneous responding, and learning and practicing emotion recognition, cognitive coping skills, and reappraisal. This program yielded reduced emotion regulation difficulties in Singaporean children with ADHD, and it was well received by the children and their families (Rosen et al., 2018). "Building Emotion and Affect Regulation" is a similar six-session program for slightly older children (Pat-Horenczyk, Sim Wei Shi, Schramm-Yavin, Bar-Halpern, & Tan, 2015); children are trained through psycho-education, experiential exercises, like role-plays, narrative techniques, and mindfulness. According to caregivers' reports children improved in emotion regulation and coping when in distress (Pat-Horenczyk et al., 2015). Finally, enhanced emotion regulation was also observed after implementing the Resilience Builder Program® (Alvord, Zucker, & Grados, 2011), a 12-week cognitive-behavioural group therapy program, designed to augment resilience, prosocial and problem-solving skills, and empathy. This has been successfully implemented in children with a diagnosis of anxiety disorder (Watson, Rich, Sanchez, O'Brien, & Alvord, 2014) or autism-spectrum disorders (Aduen, Rich, Sanchez, O'Brien, & Alvord, 2014) leading to improved emotional functioning and social skills. The effects of such a resilience-based intervention have also been assessed within the classroom setting. Kindergarten to 3rd grade students who participated in the Rochester Resilience Project Intervention showed improved teacher-reported classroom functioning, such as behaviour control and relations with their peers, and received fewer disciplinary referrals over the course of the intervention period, i.e. 4 months (Wyman et al., 2010). An important goal will be to adapt programs such as these for children earlier in development.

Mindfulness-based programs for children are also increasingly popular for enhancing their cognitive-emotional regulation. School-based programs for K-12 children have been reported to enhance children's cognitive, social, and psychological functioning (including EF, creativity, academic performance, resilience, well-being, anxiety, emotional regulation, social and relationship skills, self-concept and self-esteem), though results may vary across studies (for reviews, see Khng, 2018; Maynard, Solis, Miller, & Brendel, 2017; Meiklejohn et al., 2012; Zenner, Herrnleben-Kurz, & Walach, 2014). While less common, mindfulness-based programs have also been used in preschools to successfully promote younger children's self-regulation (including EF) and prosocial behavior—especially for children who started with poorer social competence and EF (Flook, Goldberg, Pinger, & Davidson, 2015). Related tools for children’s cognitive-emotional self-regulation can include teaching them to simply take a few deep breaths before a test—shown to reduce anxiety and enhance performance by allowing a better state-of-mind (Khng, 2017).

Outside of school, parents can play a part in cultivating children’s mindfulness. For example, resources teach mindfulness exercises for children (as young as age 5) and their parents (Snel, Kabat-Zinn, & Kabat-Zinn, 2013). Although most mindfulness programs for children start from around preschool age, parents of even younger children can foster positive outcomes for their children by cultivating mindfulness in themselves and in their parenting. (Snel et al., 2013). Although most mindfulness programs for children start from around preschool age, parents of even younger children can foster positive outcomes for their children by cultivating mindfulness in themselves and in their parenting.

Building on “Strengths”

Throughout this review, we have urged the reader to consider the adaptive nature of “problematic” children’s behavior. Though distractibility, perseveration, heightened threat detection and arousal, and prolonged distress or wariness, are often not considered “skills” in the preschool or school environment, such abilities may represent conditional adaptation to signals of a harsh environment often mediated through low levels of sensitive caregiving, limited linguistic stimulation, and poor nutrition. Thus, while we often think of children exposed to these environments as having problems—we can instead consider them to have alternative strengths (Ellis et al., 2017; Frankenhuis & de Weerth, 2013). Such a shift in mindset may open up alternative and more effective ways of teaching young children from a variety of backgrounds. Ellis and colleagues suggest a number of ways this can inform educational practice, including the teaching of the transitive property (Ellis et al., 2017). For example, when trying to teach this to children who have difficulties with abstract reasoning but are skilled at threat detection, instead of using numeric symbols (e.g., A>B, B>C, Is A >C?), they suggest teaching this concept through an environmentally relevant scenario (e.g., Jane is tougher than Sally. Sally is tougher than Betty. Who is tougher, Jane or Betty?). In this manner, educators are asked to leverage, rather than change, children’s strengths.

What’s next for “Pre” School Children? BE POSITIVE

The above approaches suggest opportunities to prepare learners and families prior to school entry. Ultimately, we must work across community, health care, and educational contexts to produce environments that signal young brains, “Be optimistic! The future will be positive!” At the same time, we must recognize that children enter school with different competencies and find ways to build upon their strengths to enhance classroom success (Ellis et al., 2017). As a step towards this goal, we, along with our colleagues at the National Institute of Education’s Centre for Research in Child Development and SingHealth Polyclinics are working towards the launch of BE POSITIVE (**BE**dok and **P**unggol **O**ngoing **S**ingaporean study beginning with **In**fants and **T**oddlers’ **I**ndividual **V**ariation and their **E**nvironment), a neighborhood study of families, recruited through polyclinics, which will capture the aforementioned early life exposures and children’s abilities, in advance of school age. We believe BE POSITIVE will add considerable value to past research. First, BE POSITIVE will focus upon frequent early life measurement of educationally relevant constructs, during stages of extremely rapid brain development. Furthermore, by recruiting from community based polyclinics, rather than childcare centres, BE POSITIVE will be positioned to understand the wide variety of caregiving contexts and early life experiences that children face. Yet, unlike hospital-based studies, BE POSITIVE is centered in the community, and leverages on an increased likelihood that the BE POSITIVE children will ultimately cluster in neighborhood preschools and schools, optimizing the potential to study the interactive effects of the home and school environment and peer-group interactions. The polyclinics are ideal sites for the study, being the main one-stop provider of a wide range of heavily subsidized primary care services to the local populations. Bedok is a matured estate with a multi-ethnic Asian population of various socioeconomic strata. In contrast, Punggol is a rapidly expanding estate populated largely by new families with young children. The respective polyclinics are located in the heart of these estates, nested close to amenities such as community libraries and childcare centres. With close proximity to their residences and easy access by public transport, neonates are brought to these polyclinics by their parents or caregivers for monitoring of neonatal jaundice as early as the third day of their lives. Subsequently, they are regularly reviewed by the polyclinic primary care teams for their scheduled immunizations and developmental assessments throughout their childhood and beyond. Working hand-in-hand with the NIE researchers, the teams of primary healthcare professionals at these polyclinics will ensure the continuity of care and robustness of data capture. The timing and setting of BE POSITIVE is well suited to enrich our understanding of the manner in which early parenting signals the “pre”school brains of our Asian pediatric population.

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