CHAPTER 9

Poverty, Early Experience, and Brain Development

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Currently, poverty affects 16 million children in the United States (DeNavas-Walt & Proctor, 2014), and a billion children globally. In the United States, *poverty* is an index defined by the federal government based on annual family income, which varies according to the number of adults and children in the home. The 2015 poverty level for a family with two adults and two children in the United States was $24,036. Interestingly, the official federal poverty level does not vary geographically, which means that neither the local cost of living nor the generosity of government-sponsored social service programs are taken into account, despite the fact that these factors vary remarkably across the United States. Because of this, investigators are actively pursuing new metrics for measuring and defining poverty. For example, the Anchored Supplemental Poverty Measure, a more complex poverty measure that includes additional variables such as tax payments, work expenses, and governmental assistance, adjusted for geographic differences, has been proposed (Wimer, Nam, Waldfogel, & Fox, 2016). Using this new measure, it was observed that childhood poverty in the United States has been reduced over the past 50 years, mainly due to governmental initiatives, but substantial disparities in the risk of poverty still remain by education level and family structure (Wimer et al., 2016). Regardless, growing up in poverty puts children at risk for a host of negative physical and mental health outcomes, as well as detrimental effects on achievement (Johnson, Riis, & Noble, 2016). In developing countries, it is estimated that over 200 million children under age 5 years do not develop properly due to the consequences of poverty (Grantham-McGregor et al., 2007).

Importantly, while poverty is (currently) defined strictly according to income, socioeconomic status (SES) typically comprises income, as well as educational attainment, occupational prestige, and subjective social status, or where one sees oneself within the social hierarchy (McLoyd, 1998; Nobles, Ritterman Weintraub, & Adler, 2013). Childhood SES has been associated with a number of broad outcome measures that are important for children's cognitive development, such as school achievement, grade retention, literacy, IQ, and school graduation rates (Brooks-Gunn & Duncan, 1997).

Indeed, longitudinal data suggest that the SES gap in cognitive development and academic achievement tends to emerge early in childhood and to widen throughout the elementary school years. For example, the British Cohort Study followed 17,200 children ages 2–10 in the United Kingdom. In a compelling analysis, Feinstein (2003) demonstrated that children from socioeconomically advantaged homes who were performing at the 10th percentile on a measure of cognitive development at age 2 tended to show increases in their cognitive abilities, relative to other children of the same age, over the course of childhood; by age 10, these children's cognitive performance was slightly above average. In contrast, children who started out at the 90th percentile at age 2 and came from socioeconomically disadvantaged homes tended to show much smaller gains over the course of childhood; by age 10, these children were performing somewhat below average. These findings imply that by age 10, child family socioeconomic circumstances are a better predictor of cognitive development than early cognitive skills.

The factors that have contributed to this gap in cognition are likely multifactorial and may be partly explained in terms of differences in nutrition (Black, 2008; Kant & Graubard, 2012; Nyaradi, Li, Hickling, Foster, & Oddy, 2013), prenatal care (Jedrychowski et al., 2009), perinatal complications (De Haan et al., 2006), gestational age (Noble, Fifer, Rauh, Nomura, & Andrews, 2012), drug exposure (Rauh et al., 2004), the home language environment (Hart & Risley, 1995; Melvin et al., 2017; Suskind et al., 2015), early education differences (Lynch & Vaghul, 2005; Schweinhart et al., 2005) and family stress (Evans, Maxwell, & Hart, 1999); as well as genetic contributions (Guo & Harris, 2000; Guo & Stearns, 2002; Tucker-Drob, Briley, Engelhardt, Mann, & Harden, 2016; Tucker-Drob & Harden, 2017; Tucker-Drob, Rhemtulla, Harden, Turkheimer, & Fask, 2011). Each of these factors has been shown to contribute in part to the link between SES and children's cognitive skills. Of course, it rapidly becomes quite complicated to attempt to uncover causal links among these highly intercorrelated factors. One way to begin to disentangle these associations is to recognize that broadband cognitive and achievement measures, such as IQ or school graduation rates themselves likely represent a conglomerate of multiple-component cognitive functions. Neuroscience tells us that distinct brain networks support different cognitive skills. By taking a neuroscience framework, we can investigate which particular cognitive skills and corresponding brain networks are most strongly associated with socioeconomic background.

In the last two decades, a number of studies have taken this approach. Researchers have recruited socioeconomically diverse families, and have administered a series of varied neurocognitive tests to children, with each task designed to evaluate a particular brain function. Results across studies have been remarkably consistent, suggesting particularly robust socioeconomic disparities from early childhood through adolescence in language skills, memory, and executive function. For example, in one sample, by the start of school, children from higher socioeconomic backgrounds tended to outperform their peers from more disadvantaged backgrounds in language, memory, and executive functions, with effect sizes ranging from 0.25 to 0.50 standard deviations (Noble, McCandliss, & Farah, 2007). Similar findings have been replicated in many laboratories across the United States and in quite a few countries around the world (Arán-Filippetti, 2012; Ardila, Rosselli, Matute, & Guajardo, 2005; Farah et al., 2006; Fernald, Weber, Galasso, & Ratsifandrihamanana, 2011; Fluss et al., 2009; Hackman & Farah, 2009; Hackman, Farah, & Meaney, 2010; Hanson, Chandra, Wolfe, & Pollak, 2011; Lipina et al., 2013; Noble & McCandliss, 2005; Piccolo, Arteche, Fonseca, Grassi-Oliveira, & Salles, 2016; Raizada & Kishiyama, 2010; Villaseñor, Sanz Martín, Gumá Díaz, Ardila, & Rosselli, 2009).

Although research in this area has grown in recent years, several questions about the associations between SES and child development remain unanswered. We address four of these questions in the remainder of this chapter. First, how early in infancy or early toddlerhood are socioeconomic disparities in child development detectable? Second, how do these differences related to differences in children's brain structure and function? Third, which experiences explain socioeconomic disparities in cognitive and brain development? Finally, how can research in this field inform interventions?

Detecting Socioeconomic Disparities in Child Development

Socioeconomic disparities in cognitive development have been reported as early as the first or second year of life (Fernald, Marchman, & Weisleder, 2013; Halle et al., 2009; Hoff, 2003a, 2003b; Noble, Engelhardt, et al., 2015; Rowe & Goldin-Meadow, 2009). For example, by 18 months of age, children from lower SES families perform more poorly than their peers from higher SES families on measures of language processing skill and vocabulary (Fernald et al., 2013). In the same study, Fernald and colleagues (2013) reported that by 24 months of age, there was a 6-month gap between low- and high-SES groups in processing skills critical to language development. A study using data from the Early Childhood Longitudinal Study, Birth Cohort (ECLS-B; Halle et al., 2009) reported disparities between low and high SES infants on language and cognitive measures by 9 months. In that study, by age 24 months there was a mean difference of 0.5 standard deviations between SES groups on the Bayley Cognitive Assessment (Halle et al., 2009). Another study found no detectable socioeconomic differences in language or memory performance between 9 and 15 months of age, but found that dramatic disparities emerged in these skills between 15 and 21 months of age (Noble, Engelhardt, et al., 2015). By 21 months, children of more highly educated parents scored approximately 0.8 standard deviations higher in both language and memory tasks than children of less educated parents (see Figure 9.1).

Experience-related differences in neural circuitry are often evident well before general cognitive or behavioral differences can be detected (Bosl, Tierney, Tager-Flusberg, & Nelson, 2011; Fox, Levitt, & Nelson, 2010). While few studies to date have investigated links between socioeconomic disparities and brain structure or function in infancy or very early childhood, one study of 44 healthy African-American one-month-old infants did find that lower SES was associated with smaller cortical gray and deep gray matter volumes (Betancourt et al., 2016). Tomalski and colleagues (2013) reported associations between SES and resting brain activity in infants as young as 6–9 months of age. Intriguingly, however, using similar electroencephalographic measures of resting brain function, Brito, Fifer, Myers, Elliott, and Noble (2016) found no socioeconomic disparities in brain function at birth. While the small sample and correlational nature of the study limit causal inference, these results are consistent with the notion that SES-related differences in brain function may emerge over time in an experience-dependent manner.

Altogether, a small but growing body of evidence suggests that socioeconomic disparities in children's cognitive and brain development may emerge early in infancy. This has implications for the timing of both screening and intervention efforts, as discussed below.

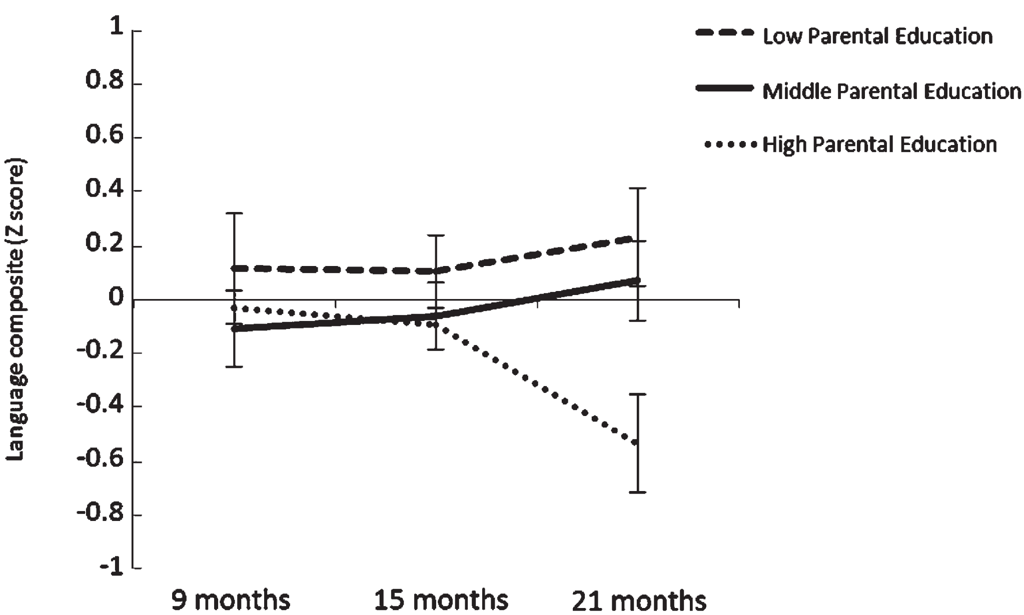

FIGURE 9.1. Children of more highly educated parents scored approximately 0.8 standard deviations higher on language tasks than their peers of less educated parents in language tasks at 21 months of age. Adapted from Noble, Engelhardt, et al. (2015, p. 12).

Socioeconomic Disparities and Brain Structure and Function

Numerous studies have now documented socioeconomic disparities in brain structure and function across the lifespan, using multiple neuroimaging techniques (for reviews, see Brito & Noble, 2014; Ursache & Noble, 2016).

Socioeconomic disparities in brain function have been documented both behaviorally and in measures of brain physiology. From a behavioral perspective, individuals from disadvantaged backgrounds tend to underperform relative to their higher SES peers in numerous cognitive tasks (Hackman & Farah, 2009; Hackman et al., 2010; Johnson et al., 2016; Ursache & Noble, 2016), such as language (Dearing, McCartney, & Taylor, 2001; Engel, Santos, & Gathercole, 2008; Farah et al., 2006; Fernald et al., 2013; Fluss et al., 2009; Hart & Risley, 1995; Hoff, 2003b, 2006, 2013; Noble, Engelhardt, et al., 2015; Noble, Farah, & McCandliss, 2006; Noble & McCandliss, 2005; Noble, Norman, & Farah, 2005; Noble, Tottenham, & Casey, 2005; Noble, Wolmetz, Ochs, Farah, & McCandliss, 2006; Pungello, Iruka, Dotterer, Mills-Koonce, & Reznick, 2009; Raviv, Kessenich, & Morrison, 2004), memory (Akshoomoff et al., 2014; Farah et al., 2006; Herrmann & Guadagno, 1997; Noble, Engelhardt, et al., 2015; Noble et al., 2007; Noble, Norman, & Farah, 2005; Turrell et al., 2002; Waber et al., 2007), and executive functions (Ardila et al., 2005; Blair et al., 2011; Evans & Fuller-Rowell, 2013; Evans & Rosenbaum, 2008; Evans & Schamberg, 2009; Farah et al., 2006; Hackman, Gallop, Evans, & Farah, 2015; Hughes, Ensor, Wilson, & Graham, 2010; Leonard, Mackey, Finn, & Gabrieli, 2015; Lipina et al., 2013; Mezzacappa, 2004; Noble et al., 2007; Noble, Norman, & Farah, 2005; Raver, Blair, & Willoughby, 2013; Rhoades, Greenberg, Lanza, & Blair, 2011; Sarsour et al., 2011; Wiebe et al., 2011). Similar findings have been reported on a neurobiological level. For example, socioeconomic disparities have been reported in individuals' hippocampus function during memory tasks (Czernochowski, Fabiani, & Friedman, 2008; Sheridan, How, Araujo, Schamberg, & Nelson, 2013); as well as in prefrontal cortex during executive functioning tasks (D'Angiulli, Herdman, Stapells, & Hertzman, 2008; D'Angiulli et al., 2012; Kishiyama, Boyce, Jimenez, Perry, & Knight, 2009; Sheridan, Sarsour, Jutte, D'Esposito, & Boyce, 2012; Stevens, Lauinger, & Neville, 2009), and in the amygdala during socioemotional processing tasks (Gianaros et al., 2008; Kim et al., 2013). In language-supporting regions, researchers have reported socioeconomic disparities in the function of frontal areas (Pakulak & Neville, 2010; Raizada, Richards, Meltzoff, & Kuhl, 2008; Tomalski et al., 2013) as well as a moderating effect of SES in the activation of the left fusiform gyrus during a reading task (Noble, Farah, & McCandliss, 2006; Noble, Wolmetz, et al., 2006). This emerging research suggests that socioeconomic conditions may shape brain functioning on both behavioral and neurobiological levels.

Socioeconomic disparities have also been documented in the structure of the brain, in addition to its function. The most commonly reported finding is a positive association between SES and the size of the hippocampus, which supports memory (Butterworth, Cherbuin, Sachdev, & Anstey, 2011; Hair, Hanson, Wolfe, & Pollak, 2015; Hanson et al., 2011; Jednorog et al., 2012; Leonard et al., 2015; Luby et al., 2013; Noble, Grieve, et al., 2012; Noble, Houston, Kan, & Sowell, 2012; Piras, Cherubini, Caltagirone, & Spalletta, 2011; Staff et al., 2012). Additional links have been reported between socioeconomic factors and the structure of prefrontal regions important for self-regulation and attention (Hair et al., 2015; Hanson et al., 2013; Leonard et al., 2015; Noble, Korgaonkar, Grieve, & Brickman, 2013), as well as between SES and left-hemisphere cortical regions that are important for the development of language (Hair et al., 2015; Jednorog et al., 2012; Noble, Houston, et al., 2012, 2015).

Much of this work has focused on examining links between socioeconomic circumstance and cortical volume. While many studies have reported significant associations (Butterworth et al., 2011; Cavanagh et al., 2013; Hair et al., 2015; Hanson et al., 2011, 2013; Jednorog et al., 2012; Liu et al., 2012; Luby et al., 2012; Noble, Houston, et al., 2012; Staff et al., 2012), others do not (Brain Development Cooperative Group, 2012; Lange, Froimowitz, Bigler, Lainhart, & the Brain Development Cooperative, 2010). Findings may be discrepant in part because different brain regions and ages have been investigated (Brito & Noble, 2014). Additionally, cortical volume represents a composite of surface area and cortical thickness, two morphometric properties that exhibit different developmental trajectories (Raznahan et al., 2011). Recent work has examined socioeconomic disparities in these more specific structural properties of the developing cortex.

In general, cortical thickness peaks around preschool age, then decreases with time, continuing to thin through early adulthood (Brown et al., 2012; Raznahan et al., 2011; Sowell, Thompson, & Toga, 2004; Walhovd, Fjell, Giedd, Dale, & Brown, 2017). In a longitudinal study, Gogtay and colleagues (2004) reported a progressive sequence of cortical thinning that began around 4–8 years of age, with the maturation, or thinning, of somatosensory and visual cortices, followed by areas that support spatial orientation and language (parietal lobes). The last areas (frontal lobes) matured during adolescence, as complex cognitive abilities (e.g., executive functions) emerge. In contrast, surface area increases rapidly during childhood, until aage 9–10 years, when it reaches a plateau, followed by a midadolescent phase of decline (Brown et al., 2012; Raznahan et al., 2011). Taking into account these differences in developmental trajectories, it is most informative to study cortical thickness and surface area separately.

To examine how SES relates to surface area, Noble, Houston, and colleagues (2015) evaluated a socioeconomically diverse sample of 1,099 children and adolescents, and controlled for genetic ancestry. Higher family income was associated with larger cortical surface area in children's brains. This relationship was particularly strong for areas that support language and executive functioning (Noble, Houston, et al., 2015), and differences in surface area partially accounted for socioeconomic differences in certain executive function skills. Furthermore, the relationship between family income and surface area was nonlinear, such that the steepest gradient was seen at the low end of the income spectrum; that is, dollar for dollar, differences in family income were associated with proportionately greater differences in brain structure among the most disadvantaged families.

Several studies have examined links between SES and cortical thickness. For example, in a sample of 283 children and adolescents, Lawson, Duda, Avants, Wu, and Farah (2013) observed that parental education, but not family income, was positively associated with cortical thickness in the right anterior cingulate gyrus and left superior frontal gyrus. In a sample of 58 early adolescents, Mackey and colleagues (2015) reported that family income was positively associated with cortical thickness in all lobes of the brain; furthermore, greater cortical thickness partially accounted for socioeconomic discrepancies in reading and math test performance. In a follow-up study using the sample of 1,099 children and adolescents referenced earlier, Piccolo, Merz, and colleagues (2016) reported that SES moderated patterns of age-associated change in cortical thickness. Specifically, at lower levels of SES, a curvilinear pattern of relatively steep age-related decrease in cortical thickness was observed earlier in childhood, with a subsequent leveling off during adolescence. In contrast, at higher levels of SES, associations between age and cortical thickness were linear, with more gradual decreases in cortical thickness at younger ages, with continued cortical thinning through late adolescence. One possible explanation of these findings is that early adversity may narrow the time window when experience-dependent process shapes development and/or accelerate maturation (Callaghan & Tottenham, 2016).

Of note, many of these studies indicate wide variation in brain development between individuals, even within socioeconomic strata. For example, in a secondary analysis of the 1,099 participants from Noble, Houston, and colleagues (2015), moderation analyses indicated that the impact of SES varies across cortical thickness, with SES more strongly predictive of executive function skills among children with thicker cortices and more strongly predictive of language skills among children with thinner cortices (Brito, Piccolo, & Noble, 2017). Thus, socioeconomic disparities—and the experiences for which they likely serve as a proxy—represent just one mechanism that may lead to individual differences in brain development.

Experiences Shaping Poverty-Related Differences in Cognitive and Brain Development

The link between family socioeconomic circumstance and children's brain development is likely based at least in part in differences in experience. As mentioned earlier, numerous factors may contribute to these links (nutrition, health care, material resources, etc.). Although an exhaustive review of the different possible mechanisms is beyond the scope of this chapter, we next review the evidence for two possible types of experience that may mediate these links, namely, the home linguistic environment and family stress. Figure 9.2 illustrates a theoretical model illustrating these putative links (Noble, Houston, et al., 2012). In brief, the quantity and quality of language that children hear is likely important for shaping development of neural networks that support the development of language skills. Simultaneously, socioeconomic disadvantage is associated with greater exposure to family stress. Stress, in turn, has important effects on the hippocampus (supporting memory development), as well as the prefrontal–limbic circuitry that supports the development of self-regulation.

SES, the Home Language Environment, and Language Development

It is well documented that children from lower SES homes tend to be exposed to a lower quantity and quality of linguistic input (Goldin-Meadow et al., 2014; Hart & Risley, 1995). It has been estimated that by age 4, children from disadvantaged homes hear 30 million fewer words than their more advantaged peers (Hart & Risley, 1995). In addition, the complexity of the verbal interactions, as well as the responsiveness or the conversational nature of the verbal interactions, seems to vary as a function of SES (Evans et al., 1999; Perkins, Finegood, & Swain, 2013). Furthermore, the number of words children hear has been directly related to their vocabulary size (Arriaga, Fenson, Cronan, & Pethick, 1998; Fernald et al., 2013; Hoff, 2003b, 2006, 2013). For example, the amount of speech parents direct to their children before the age of 3 years accounts for over half of the variance in children's cognitive performance and vocabulary at 9 years of age (Hart & Risley, 1995).

Research linking the home linguistic environment to brain development is in its infancy. However, some work suggests that one-on-one social interaction is critical for shaping the development of language supporting brain function (Kuhl, Tsao, & Liu, 2003). A recent study investigated whether the home environment might explain SES differences in brain structure. In a longitudinal design, cognitive stimulation in the home environment (as measured by HOME Inventory) at age 4 predicted cortical thickness in temporal and prefrontal cortex in late adolescence (Avants et al., 2015). Future work is required to determine specific features of the home language environment that may account for these links.

SES, Stress, Memory, and Executive Function Development

Although short-term response to stress can be adaptive, chronic exposure to high degrees of stress contributes to the emergence of physical disease and dysfunction (McEwen, 1998). Children raised in families with lower socioeconomic backgrounds are often exposed to a higher degree of family stress, including increased exposure to neighborhood violence, chaos in the home, mental health problems and unstable relationships. When families are exposed to high levels of stress, their familial relationships tend to be characterized by conflict or emotional withdrawal rather than with the warm and nurturing relationships that are important for children's development (Biglan, Flay, Embry, & Sandler, 2012; Farah et al., 2008; Hackman et al., 2010).

A number of reports suggest that disadvantaged children may have altered levels of stress

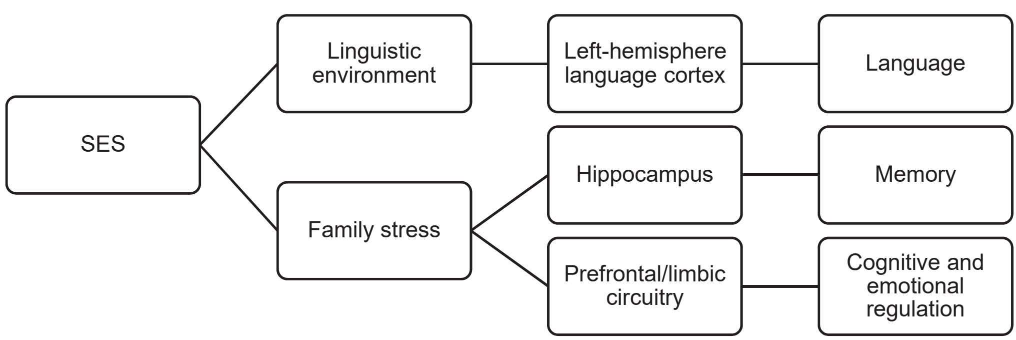

FIGURE 9.2. Mechanisms underlying SES effects on structural and functional brain development: theoretical model. Adapted from Noble, Houston, Kan, et al. (2012, p. 2).

hormones, such as cortisol (Blair & Raver, 2016; Juster et al., 2016; Lupien, King, Meaney, & McEwen, 2001; Vliegenthart et al., 2016). Several neural networks are particularly sensitive to cortisol. For example, high levels of cortisol have been associated with impaired functioning of the hippocampus, amygdala, and prefrontal areas, leading to impairments in memory, executive functioning, and emotion regulation (Blair et al., 2011; Gianaros et al., 2007; Liston, McEwen, & Casey, 2009; Lupien et al., 2001; Lupien, McEwen, Gunnar, & Heim, 2009; McEwen & Gianaros, 2010; Sheridan et al., 2013; Tottenham & Sheridan, 2009). It is therefore possible that socioeconomic disparities in exposure to stress may lead to alterations in cortisol, which in turn have cascading effects on these neural systems and the cognitive and emotional skills they support. Additionally, studies have reported that the perception of stress may drive these physiological consequences. In general, there is evidence that perceived stress is associated with deleterious effects on cognitive outcomes (Aggarwal et al., 2014; Korten, Comijs, Penninx, & Deeg, 2017; Merz, Tottenham, & Noble, 2018; Munoz, Sliwinski, Scott, & Hofer, 2015; Rubin et al., 2015) as well as with decreased hippocampal volume (Gianaros et al., 2007; Lindgren, Bergdahl, & Nyberg, 2016; Luby et al., 2013; Pagliaccio et al., 2014; Piccolo & Noble, 2018; Zimmerman et al., 2016) and prefrontal cortex (Gianaros et al., 2007; Moreno, Bruss, & Denburg, 2017). The association between perceived stress and amygdala is controversial, and results vary according to the studies' analysis techniques, brain regions evaluated, and the gender and age of the sample, with some work reporting increased perceived stress related to smaller (Pagliaccio et al., 2014) and other research with larger amygdala volume in children (Tottenhan et al., 2010) and other works finding no association between perceived stress and amygdala volume (Luby et al., 2013; Piccolo & Noble, 2018).

Importantly, the home language environment and family stress pathways are unlikely to be independent (Figure 9.2) (Evans et al., 1999; Perkins et al., 2013). For example, crowding in the home is associated with psychophysiological stress (Evans, Lepore, Shejwal, & Palsane, 1998) and reduced language diversity (Evans et al., 1999). Parents from crowded homes spoke in less complex and sophisticated ways with their children, and tended to be less verbally responsive to their children when compared to parents from less crowded homes.

Implications for Interventions

If we believe that SES disparities are likely leading to differences in experience, which in turn help to shape brain development and behavior, then the question is how such experiences can be modified, and what is the right level at which to intervene (see Figure 9.3)?

Most commonly, interventions aimed at reducing socioeconomic gaps in achievement have been implemented in the form of educational interventions. High-quality early childhood education can lead to dramatic improvements in children's academic success and lifelong well-being (Lynch & Vaghul, 2005; Schweinhart et al., 2005). However, due in part to the scarcity of publicly available programs, not all children receive high-quality early education, and low-income children are the least likely to be enrolled (Meyers, Rosenbaum, Ruhm, & Waldfogel, 2004). However, children from disadvantaged families are also more likely to benefit most from early education (Magnuson & Waldfogel, 2005; Ruhm & Waldfogel, 2012). It has been estimated that policies targeting low-income families and expanding access to high-quality early education could close between 20 and 36% of the school readiness gaps (Magnuson & Waldfogel, 2005).

In this regard, one commonly cited example is the High/Scope Perry Preschool study, which has followed 123 children born in poverty for more than 40 years. At ages 3 and 4, the subjects were randomly divided into a group that

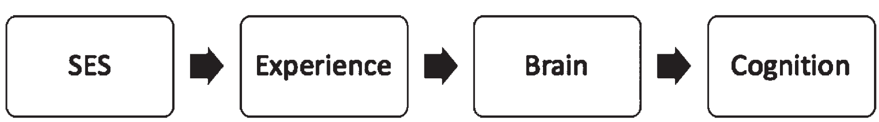

FIGURE 9.3. Possible levels of intervention for SES disparities on cognitive development.

received an intensive, high-quality preschool program and home visits, and a comparison group that received no preschool program. At age 40, participants who were randomized to the treatment group had higher wages, were more likely to hold a job, had committed fewer crimes, and were more likely to have graduated from high school than adults who did not attend preschool (Schweinhart et al., 2005). These benefits were quite cost-effective—for every dollar invested, there was a return of nearly $13. However, the pragmatics of scaling up such intensive programs to the larger population while maintaining high quality is a frequently cited concern. Other studies have suggested that a less intensive (and potentially more scalable) approach can still be beneficial. For example, the Chicago School Readiness Project was a classroom-based intervention providing Head Start teachers with training on effectively managing dysregulated behavior. In an evaluation using a cluster-randomized controlled trial design, investigators found that the program led to gains in not only executive functioning and impulsivity but also preacademic skills, despite the fact that these skills were not explicitly targeted (Raver et al., 2011). Similarly, the Boston Public Schools' prekindergarten program has used research-based curricula and coaching of teachers' approach. In a study with more than 2,000 4- to 5-year-old children enrolled in the program, Weiland and Yoshikawa (2013) found moderate to large improvements in children's language and math performance, as well as small impacts on executive and emotional development skills.

High-quality early childhood education clearly plays a critical role in reducing socioeconomic disparities in achievement (Engle et al., 2011). However, when we consider that socioeconomic disparities in language skills are already clearly apparent by the second year of life (Fernald et al., 2013; Halle et al., 2009; Hoff, 2003b; Noble, Engelhardt, et al., 2015; Rowe & Goldin-Meadow, 2009), we can argue that if we are waiting until children start formal school to invest in interventional approaches, we are likely waiting too late.

To intervene earlier in childhood, one might focus on changing children's experiences through, for example, parenting interventions. Indeed, dozens of such interventions have been designed and evaluated, many of which tend to be quite effective (Lundahl, Tollefson, Risser, & Lovejoy, 2007). For example, the large-scale Nurse–Family Partnership home visiting program has led to moderate improvements in children's cognitive and behavioral outcomes (Olds et al., 2014). Other programs, such as Reach Out and Read (Zuckerman, 2009; Zuckerman & Khandekar, 2010), and its expansions, such as the Video Interaction Project (Cates, Weisleder, & Mendelsohn, 2016; Mendelsohn et al., 2007) have taken advantage of the fact that the pediatric primary care setting represents an accessible, high-engagement, and potentially scalable venue for interventional services. For even the best-designed parent-focused programs, however, there are inherent challenges of uptake and attrition when targeting disadvantaged families whose lives are often characterized by psychological strain and lack of routines (Kalil, Duncan, & Ziol-Guest, 2016).

A final avenue for directing interventions may be at the most distal level, namely, through changing SES itself. A great deal of work using longitudinal data and natural variation in family income has suggested that early childhood differences in family income are robust predictors of children's later achievement, educational attainment, and even adult earnings (Duncan, Yeung, Brooks-Gunn, & Smith, 1998; Duncan, Ziol-Guest, & Kalil, 2010). Quasi-experimental evidence from the welfare-to-work experiments of the 1990s suggests that income increases led to improved achievement and schooling outcomes, with a $4,000 increase in annual income (in current dollars) for 2–3 years, increasing school achievement by 0.18 standard deviations (Duncan, Morris, & Rodrigues, 2011; Morris, Duncan, & Clark-Kauffman, 2005). Children from families with increased income tended to spend more time in the labor market as adults (Dahl & Lochner, 2012), and even showed evidence of improved health in adulthood (Ziol-Guest, Duncan, Kalil, & Boyce, 2012).

In this regard, one promising approach may to be to focus on supplementation of income itself as a means to improve children's developmental outcomes. Such unconditional or conditional cash transfers have been tested in developing countries and have often produced significant improvements in children's education and health (Fiszbein, Schady, & Ferreira, 2009). Such a program might be expected to lead to changes in the family via two primary pathways. First, increased opportunities for material investment may enable families to purchase more nutritious foods, buy more books and toys, and afford better child care and better housing in better neighborhoods. Second, extra income may reduce psychological strain and stress that families and children experience, enabling parents to be present and engaged with their children in warmer, more nurturing ways. If an evaluation of such a cash transfer program did indeed produce meaningful results, findings could inform debates on the generosity or cuts to existing or new social service programs that affect families with young children in the United States and around the world. While increased family income may not be the most important factor in shaping children cognitive and brain development, it may represent a highly scalable intervention to help children overcome the consequences of living in poverty.

Conclusions

The developing brain is intensely affected by experiences in the first years of life. On the one hand, children are vulnerable to environmental adversity. On the other hand, the early childhood years represent an important time window for parents, teachers, communities, and policymakers to create healthy and stimulating learning environments that promote the ability of children to reach their full potential. A large body of evidence shows that multiple aspects of early skills—achievement, behavior, and mental health—if improved early in life, can improve lifelong well-being and development. Support for early childhood development and education programs can produce large benefits to children, parents, and society. Our global economic future depends on providing such tools for building a highly educated, skilled workforce.

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