Parental Language and Learning Directed to the Young Child

Dina Kapengut and Kimberly G. Noble

Summary

The early home language environment, and parents in particular, form the foundation of children's language development. In this article, Dina Kapengut and Kimberly Noble explore the intersection of neuroscience and developmental psychology to explain how language experiences in the home, and the *home learning environment* more broadly, shape young children's brains and, ultimately, their developmental and academic outcomes.

Brain plasticity during childhood makes the brain particularly sensitive to environmental influence. Because socioeconomic inequality is associated with variation in environmental exposures and experiences that are particularly powerful in predicting children's outcomes, the authors write, children from socially and economically disadvantaged backgrounds are at a profoundly increased risk for negative physical, socioemotional, cognitive, and academic outcomes. This harmful pattern emerges early, compounds over time, and persists into adulthood.

Fortunately, a number of interventions show promise for helping parents improve the home learning environment. Kapengut and Noble highlight several evidence-based programs, most of which focus on the concept of *language nutrition*—a term created by pediatricians to explain to caregivers that exposure to language that's rich in quality and quantity and delivered in the context of social interactions is crucial for children's development and health. They also note the limitations of existing programs and of the research behind them, and they suggest where policy makers, practitioners, and researchers could look to narrow socioeconomic-related differences in home learning environments.

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Child development is the product of the continuous dynamic interplay of biological factors, environmental contexts, and social relationships that a child experiences from the beginning of life. Parents are children's first and most important teachers, providing the at-home context through which children investigate the world, thereby creating a blueprint for learning and behavior. This *home learning environment* reflects a child's interactions in and around the home and contributes substantially to children's learning and overall development. Differences in the home learning environment, especially differences between lower- and higher-income families, play an important role in children's academic and eventual economic success.

The incorporation of neuroscience into developmental science has helped us better understand the link between experience and development. The young brain is physiologically predisposed to attend to certain aspects of the environment, particularly interactions with caregivers. The influence of the home learning environment on children's learning and achievement likely arises from specific downstream experiential effects on structural brain development. That is, the home learning environment comprises parenting and family experiences, which ultimately shape the young child's brain.

Examining the early influences on academic achievement that occur before the start of school can help policy makers, professionals, and parents understand how the home learning environment and interactions with young children affect language development and overall school readiness.

The Importance of the Home Learning Environment

The home learning environment encompasses an array of characteristics, including hands-on parenting behaviors such as reading to children or exhibiting responsiveness and warmth in interactions, as well as more indirect practices such as making learning materials available in the home. We focus here on literacy and language development, as language skills are among the best predictors of school readiness and academic outcomes. Moreover, linguistic stimulation is a prime candidate mechanism that may link the home environment with children's language-related brain structure and academic outcomes.

Much of the research on language and learning in the home is based on school-age children. We therefore primarily examine parental practices associated with fostering language and emerging literacy skills, while highlighting the rarer findings from research on infants and toddlers. It's important to note that parent-child learning activities may foster development both by helping children with specific skills and by developing the motivation necessary for learning and achievement generally.

Parent-Child Communication and the Home Learning Environment

Language acquisition is a dynamic process by which children construct meaning out of interactions with caregivers. To do so, children must come to recognize that language is a social tool that

enables them to share intentions with those around them. Yet infants aren't inherently aware of social pragmatics, nor are they inherently equipped with the understanding that language is a communication tool. As infants learn that meanings have shared intentionality, they engage in actions that elicit their caregiver's attention and knowledge. They look where their parents look, refer to and seek guidance from parents in ambiguous situations, and use gestures and words to share experiences. Moreover, from birth, infants prefer to listen to infant-directed speech over adult-directed speech, and the perceptual-attentional effects of infant-directed speech are linked to children's later language outcomes. In this way, social interactions with caregivers teach infants that language is socially shared, thereby facilitating their possibilities for and achievement of language acquisition. As such, the social brain is said to "gate" language learning, underscoring the transformational role that parents play in promoting the underlying neural systems needed to acquire language.

University of Kansas researchers Betty Hart and Todd Risley famously estimated that by the age of four, children in lower-income families have heard 30 million fewer words than their more affluent peers. The researchers found that this word gap was strongly associated with children's language outcomes. Three-year-olds in lower-income families had less than half the vocabulary of their counterparts in higher-income families, and the amount of speech that parents directed to their children in the first three years of life accounted for over half of the variance in children's cognitive performance and vocabulary at three and nine years of age. Furthermore, these at-home differences in linguistic stimulation predicted differences in cognitive development and vocabulary scores, which later translated to differences in academic trajectories.

Children benefit from exposure to frequent, varied, and complex adult speech.

The association between socioeconomic factors and quantity of linguistic stimulation in the home has been extensively investigated. Parents from wealthier backgrounds are likely to talk more with their children, and tend to use more extensive vocabulary, longer sentences, and more complex grammar, than do parents from disadvantaged backgrounds. Longitudinal studies, in which researchers repeatedly observe participants over months or years, further the notion that children benefit from exposure to frequent, varied, and complex adult speech. Comprehensive longitudinal studies have found that the *quality* of language input is often an even stronger predictor of children's language skills. Both the quantity and quality of adult speech that children hear have been found to mediate associations between family socioeconomic status (SES) and children's language skills.

Early communication quality differs within income groups as well. Among low-income families, the quality of language input at age two has been used to predict children's language development at age three. Although a small association has been reported between the quantity of language input and the number of adults with whom

children interact, descriptive studies haven't found a significant difference in language input between single-parent and multiple-parent households, after controlling for socioeconomic factors.

In an analysis of thousands of homes from the 1979 Children of the National Longitudinal Survey of Youth, differences in children's vocabulary were related to the home language environment at age three, and these differences remained stable through the age of 13. Recent research has found further links between infant-directed speech and later language skills. One small study found that even among preterm infants, a greater adult word count in the first months of infancy was associated with higher cognitive and language scores in the first and second years of life. Simply put, differences in the home language environment lead to early differences in language and reading-related skills, which in turn serve as precursors of later academic achievement. One longitudinal investigation of child-directed speech among 50 pairs of parents and children found that quantity of parental input was most important during the child's second year of life, while diversity of parental vocabulary was more important in the third year and the use of abstract language was most important in the fourth year.

Literacy Activities and the Home Learning Environment

Early reciprocal verbal interactions occur through games, nursery rhymes, songs, daily conversations, and book reading, all of which promote foundational literacy skills. This effect may begin as early as the prenatal period: An investigation of 33 mother-infant pairs reported that newborns preferred a passage that their mothers had read aloud each day during the last six weeks of pregnancy over a novel passage. As infants get older, shared book reading and exposure to print help them learn letters, which affects their later ability to decode words. A review of dozens of published studies on the frequency of shared reading found that joint book reading in the home is associated with children's vocabulary size, phonemic awareness, and overall reading achievement.

In a large-scale study of Early Head Start families, researchers found that daily reading to children in the first, second, and third year of life predicted children's language and cognition at age three. Specifically, analyses suggested a reciprocal and snowballing relationship between mothers' book reading and children's vocabulary—early reading was linked with increased vocabulary, which in turn was associated with more reading. In a similar large-scale investigation of more than three hundred Head Start families, the frequency of shared book reading, earliest age of picture book reading, number of picture books in the home, children's requests for book reading and their play with books, shared trips to the library, and parents' own personal reading habits all accounted for variability in young children's language skills, suggesting that these aspects of the home literacy environment may be prime targets for intervention.

Parental Engagement in the Home Learning Environment

Among infants and young children, exposure to language from television isn't associated with beneficial effects, suggesting that the social element of human interaction is

integral to positive language development. Yet findings show that toddlers can learn new words over video calls, which demonstrates that the key factor of social interaction isn't physical presence, but social contingency. Specifically, toddlers can learn new words over video calls if the conversation is contingent and meaningful, as opposed to noncontingent video. In another study, the quality of infants' vocalizations was directly related to a mother's contingent response, as opposed to a delayed one. Research extends this contingency to newborns, who demonstrably prefer the sound of their mother's voice. These studies suggest that social behaviors associated with infant- and child-directed speech, such as pitch, parental speech characteristics, and responsiveness, likely play a significant role in language development.

One small longitudinal study of parent-child interactions found that the quality of such interactions more closely predicted early literacy skills than did reported home literacy experiences. Recent research corroborates the notion that differences in early language environments aren't limited to the quantity of input but extend to the quality of social interactions and exchange as well. For example, in the same study that identified a 30-million-word gap, Hart and Risley found that children in low-income households heard twice as many prohibitions as affirmative statements from their parents than did children in middle- and upper-income households. Additionally, children in higher-SES families tend to experience more gestures by their caregivers, and differences in early gestures accounted for socioeconomic disparities in children's later vocabulary knowledge. One recent study reported that the quality of the home language environment, but not SES, predicted infant's early language skills.

Thus, although the overall number of words children hear varies widely and is important, the quality of social language interactions may be an even more powerful predictor of developmental outcomes. (The following section touches on how parental engagement may be the catalyst for children's language acquisition, but see Megan Gunnar and Carrie DePasquale's article in this issue for a more comprehensive review of the effects of parental sensitivity and nurturance.)

Parental responsiveness promotes and modulates infants' communication skills even before the infants produce conventional words. When they begin to babble and then speak simple phrases, responsiveness predicts the size of infants' vocabularies, the diversity of infant communications, and the timing of language milestones. Longitudinal studies have suggested that regardless of socioeconomic background, infants who have highly responsive mothers achieve language milestones—including first words, vocabulary spurt, and combinatorial speech—four to six months earlier than infants of mothers who are less responsive or inconsistently so. Notably, these developmental differences persisted through age eight.

Affective aspects of parent-child interactions and communication, including emotional tone and parental warmth, also relate to child development. A longitudinal investigation of 40 mother-infant pairs found positive associations between warm, sensitive parenting and children's language abilities in infancy. One study of over a hundred families found that one- and two-year-old

children of mothers who were observed to be more sensitive experienced faster rates of development of expressive and receptive language from 18 to 36 months. In early childhood, maternal sensitivity and sensitive parenting have repeatedly been found to be significantly associated with expressive and receptive language and vocabulary scores. Importantly, parental sensitivity isn't simply a measure of cognitive stimulation; in fact, maternal sensitivity and cognitive stimulation are independently related to children's language outcomes at age four.

Among children in lower-SES households, sensitive parenting—or the presence of a supportive caregiver—has consistently been shown to promote more resilient long-term outcomes.

Responsive caregiver-child interactions may facilitate language learning by motivating infants to engage in social interaction. A positive affect on the parents' part promotes learning, whether by increasing attention, fostering enthusiasm in the child, or another mechanism; a negative affect deters learning. Thus parents' strategies that support children's early language skills include a number of language-specific scaffolding behaviors—that is, behaviors that support the child's development and taper off as the support becomes unnecessary, such as emphasizing the names of letters. But these strategies also include behaviors such as positive affect, expressions of warmth through physical closeness, sensitive voice tones, and appropriate pacing. Given the substantial evidence that sensitive interactions, defined by warmth and responsiveness, predict language abilities, parenting interventions have also promoted parental engagement in the home.

Among children in lower-SES households, sensitive parenting—or the presence of a supportive caregiver—has consistently been shown to promote more resilient long-term outcomes. Specifically, parental warmth and sensitivity can promote reading acquisition in children from low-SES homes, potentially buffering against risk for delays in language skills. A recent study of 145 children found that nurturing care and certain interactive and supportive features of communication (for instance, praise) serve as a buffer against poverty by promoting healthy brain development. Moreover, a study of over four hundred children found that positive caregiver-child language interactions in childcare settings that serve children from disadvantaged backgrounds can buffer against poor language outcomes. This buffering effect was especially strong for children who received limited language input at home.

Critically, the benefits of parenting aren't merely epiphenomena of genetic heritability. Parental sensitivity affects the verbal skills of adopted children, predicts infant learning under laboratory manipulations, and enhances children's language skills in interventions that target responsiveness. Collectively, caregiving drives children's language development; moreover, caregiving is linked with early academic achievement. As such, we need to investigate the paths by which caregiving impacts child outcomes.

Learning Materials in the Home Learning Environment

The home learning environment includes factors beyond direct interactions with parents. For instance, a broad investigation of four-year-olds attending Head Start found that the number of picture books in the home predicted children's language skills and vocabulary. Furthermore, early exposure to toys that promote symbolic or pretend play (such as cooking sets) and fine motor skills (such as blocks) is linked to children's early receptive language skills. Resources that can provide cognitive stimulation or extend the home learning environment into other venues, such as outings to libraries, museums, or parks, have also been linked to improved child outcomes. But compared to research on the role of parental engagement, communication, and early literacy experiences, the research on the effect of learning materials is relatively limited.

Given the ubiquity of digital technologies, learning materials today may include computers, mobile devices, and other electronics, though a full review of the developmental impacts of media is outside the scope of this article. The advantages and disadvantages of media and technology are numerous and hotly debated. But here we're concerned with how technology affects child-directed speech and parental engagement as it relates to the home learning environment. A large investigation based on parental reports found that increased use of digital technology by parents predicted more technology-based interruptions in both mother-child and father-child interactions; in turn, interruptions in mother-child interactions predicted children's conduct, both emotional and behavioral. In addition, several small studies have linked early television exposure with substantial reductions in the quantity and quality of parent-child interactions, which in turn may be what underlies findings that increased media exposure during childhood is associated with lower language skills. If frequent media exposure disrupts language development by reducing the quality and quantity of parent-child verbal interactions, the rising ubiquity and ever-increasing role of technology in families' lives demands further research on how early technology exposure impacts children's long-term developmental and neural outcomes.

Children's Language Experiences and the Developing Brain

The developing brain undergoes a competitive neural process. Neuronal connections that remain inactive or are rarely activated are eliminated, whereas those that are actively stimulated by experience are strengthened and maintained. In this way the developing brain is remarkably responsive to interactions with the environment, and its structure is altered by such experiences in measurable ways. Simply put, each person's brain comes to reflect a unique experiential history. Thus children's early environmental experiences, including parenting and the home environment, are critical to neurodevelopment. Brain plasticity during childhood makes the brain particularly sensitive to environmental influence, especially that of the social-affective or caregiving environment. In this section we discuss how the home language environment, literacy activities, parental engagement, and learning materials have been associated with changes in both neural

activity and neural structure related to language acquisition.

Much of what we know about how variations in caregiving can affect brain development and behavior is based on animal research. For example, studies show that rats raised in enriched conditions—with numerous toys and cognitively stimulating tunnels and ladders—have greater neural complexity in a number of brain regions than do animals raised in impoverished environments. These changes persist well beyond exposure to the enriched environment.

In infancy, variations in maternal care and parent-child interactions are thought to help shape neural structures and circuits by influencing epigenetic programming—that is, they serve as nongenetic, environmental influences on gene expression. In rodents, for example, increased maternal grooming, which is an attentive and nurturing parental behavior, has been linked with epigenetic and neural changes. Animal studies further suggest that certain effects of life experiences on myelination—a process that speeds the transmission of neural signals—are not found in mature rats, suggesting that there may be a critical period during which alterations in parenting and environment particularly influence specific aspects of brain development. Overall, evidence across species demonstrates that caregivers regulate the neurodevelopment of those in their care.

In humans, family experiences and the home environment influence children's developmental outcomes, and research has shown that the developing brain is especially sensitive to environmental factors. Socioeconomic inequality is associated with variation in environmental exposures and experiences that are particularly powerful in predicting children's outcomes. Children from socially and economically disadvantaged backgrounds are at a profoundly increased risk for negative physical, socioemotional, cognitive, and academic outcomes. This harmful pattern emerges early, compounds over time, and persists into adulthood.

Socioeconomic factors, including parental education and family income, exert their effects on child development via psychological, social, and environmental contexts, which may then impact brain regions related to cognitive, academic, and social functioning. Recent research shows that socioeconomic background plays a role in shaping children's brain structure and function. For example, socioeconomic disadvantage has been associated with reduced cortical gray matter, as measured in terms of volume, thickness, and surface area. Indeed, poverty has been linked to structural differences in numerous areas of the brain associated with school readiness skills and learning—as much as 20 percent of the observed SES gap in student test scores may be explained by lags in children's neurodevelopment. Such SES-linked changes don't suggest damage; rather, they reveal evidence of neuroplasticity, or the brain's ability to adapt in response to environmental differences, especially during childhood. Thus many neural changes may be not only preventable but also reversible.

Socioeconomic disparities are especially prominent in certain brain structures and circuits. Cortical structures underlying language comprehension, language

production, and reading are among the brain regions most commonly reported to vary by family socioeconomic circumstance.

What experiences account for links between socioeconomic disparities and children's brain structure and function, particularly with regard to regions of the brain that support language and literacy? Parent-child verbal interactions represent a key environmental mechanism that has been repeatedly linked with both family socioeconomic circumstance and children's language development.

One small study found that greater language input was associated with infants' brain responses during a phonological task. Another study reported a relation between children's videotaped home language and neural activation during a complex, nonverbal task. More recently, a functional neuroimaging study of 36 four- to six-year-old children found that at all SES levels, adult-child "conversational turns," in which the adult and child take turns speaking in a back-and-forth interaction, were associated with greater activation of a language-related brain region during a story listening task, but that higher SES was associated with more such turns. At a structural level, a greater number of adult-child conversational turns was related to stronger, more-coherent connectivity in the brain's white matter, even when controlling for SES and the overall amount of adult language input. In a study of gray matter structure among 42 five- to nine-year-olds, children who experienced more conversational turns per hour had significantly greater surface area in language-related brain regions, with a 15 percent larger effect than seen with the number of words spoken hourly by adults. Furthermore, this effect wasn't driven by the number of vocalizations made by the children on their own, suggesting that the association between conversational turns and children's brain structure didn't merely reflect a mechanism by which talkative children engendered more parental conversation. Taken together, these findings suggest that the reciprocal, back-and-forth nature of conversational turns is notably more important for language development than just the quantity of adult speech.

Reciprocal adult-child interactions seem to be especially important for language development, representing a cornerstone of children's language-related neurobiological development.

Reciprocal adult-child interactions thus seem to be especially important for language development, representing a cornerstone of children's language-related neurobiological development. This effect may occur at least partly because such communicative exchanges increase the opportunities for children to practice language and receive feedback from adults. In turn, this creates a feedback loop to help adults hone their own speech to the level of complexity that best supports children's language development. Moreover, at-home language input has been found to significantly mediate the association between parents' education and children's language-related cortical surface area, and to be indirectly associated with children's reading skills, thereby illustrating a potential mechanism

underlying socioeconomic disparities in children's reading and language. Together, these findings provide support at the neural level for hypotheses about how children's early language experiences at home may alter language-supporting brain structure, affecting children's language and reading outcomes.

SES has been reported to moderate the relationship between phonological awareness and brain activity in language-related regions. Here, the findings suggest that decreased access to resources may amplify risk factors for poor reading, whereas children with greater access to resources had stronger reading skills, irrespective of their phonological awareness scores. Thus language and literacy practices likely have a buffering effect among children with weaker phonological awareness.

Less research has examined how the quality of the physical home environment influences neurodevelopment. But one recent study found that adolescents who faced more physical problems in the home (such as structural hazards, crowding, excessive noise, or poor lighting) had a thinner brain cortex in regions critical to reading and language skills. And, indeed, these neurobiological differences were associated with lower levels of reading achievement, independent of SES and psychosocial factors.

Finally, social interaction is also closely tied to the neural mediators of language learning. Some studies suggest that neuroanatomical maturation may rely critically on social exchanges of linguistic information, rather than purely passive exposure to speech. For instance, engagement with tutors, as shown through shifting eye gaze from the tutor's eyes to newly introduced toys, is correlated with the brain activation related to language learning. Another recent study with a few dozen nine-month-olds found neural evidence that learning is enhanced in the presence of a peer, even when the learning comes from a video screen. Collectively, these findings suggest that children are motivated by, attend to, and benefit from interactions with attuned, engaging social partners, and that this phenomenon is reflected in the developing brain.

Emerging research also suggests that everyday variation in parenting quality relates to children's brain structure. For example, higher levels of parental sensitivity and parent-child attachment security have been linked with larger total brain and grey matter volumes in children. Most studies investigating the association between parental sensitivity and brain development have examined the hippocampus and other subcortical structures, which aren't directly responsible for language development. But differences in these structures may explain the links between parental sensitivity, on the one hand, and the overall learning and memory needed to succeed in school, on the other. Such findings suggest that children's early caregiving environments could be a crucial target for early intervention programs that seek to close the achievement gap, because efforts to increase children's exposure to conversation may capitalize on the neural plasticity that underlies cognitive development.

Parent-Directed Interventions

Parenting and, more broadly, the early caregiving environment lie at the heart of children's language development trajectories. Thus parents are positioned as principal agents of change in their children's

development, and evidence suggests that parent-directed interventions can effectively enhance child outcomes. This section explores the efficacy of parent-directed interventions and their potential to bridge the achievement gap between children from lower- and higher-SES homes.

One of the most notable such interventions is Early Head Start, which includes programming that encourages parents to read to and communicate more with their children. Mothers in the program have reported conducting more stimulating activities with their children than did mothers in control groups, and participation enhanced children's language skills at two, three, and five years of age. Moreover, mothers participating in Early Head Start were more likely to read to their children daily and to initiate teaching activities at home. Older home-visiting programs also featured a language component. (See a previous *Future of Children* issue for a review.) Although several large-scale interventions included a child-language component, here we focus on interventions that target parent-child communication and, specifically, on language as an outcome of interest.

Interventions generally fall into one or more of five categories:

1. Book distribution programs with anticipatory guidance for shared book reading and increasing the physical environment quality in the home;

2. Teaching dialogic reading techniques;

3. Coaching parents to talk more with their children;

4. Training parents to be responsive when their children initiate communication; and

5. Public awareness campaigns geared toward increasing parental knowledge of child development.

We highlight several evidence-based programs, most of which focus on the concept of *language nutrition*, a term created by pediatricians to explain to caregivers that exposure to language that's rich in quality and quantity and delivered in the context of social interactions is crucial for child development and health. Moreover, health care professionals have used their positions on the front lines of caregiving to provide parenting interventions in pediatric primary care. As trusted sources of information for families, pediatricians are well positioned to deliver evidence-based information about development before children enter school. Such programs have, for instance, promoted positive parenting through reading aloud and play from birth to five, and they've demonstrated positive and sustained impacts on behavioral and social-emotional development.

In fact, several initiatives have used the concepts of language nutrition and *quantitative linguistic feedback* as key components. Because it's the combination of quantity and quality in a child's early language environment that leads to optimal cognitive and educational outcomes, linguistic feedback interventions are typically designed to significantly increase adult language quantity to provide a foundation on which to layer qualitative behavioral strategies. Quantitative linguistic feedback is a behavioral strategy

that uses the Language Environment Analysis (LENA) technology as a sort of "linguistic pedometer." The LENA, a digital recording device and software package, tracks the number of words a child is exposed to, along with the number of conversational turns the child takes with adults, for up to 16 hours. Many interventions targeting parent-child communication quantity and quality use the measures of parent speech obtained from LENA to give parents concrete feedback about their home language environment. In this way, the LENA measures can serve as a type of biofeedback, helping parents establish concrete goals and monitor their progress toward achieving those goals.

One such evidence-based parent-directed intervention, named TMW after the 30-million-word gap described above, aims to encourage children's language development by narrowing that gap and increasing child-directed speech. The initiative not only relies on interpreting feedback from LENA recordings, it also combines education, technology, and behavioral strategies to lay the foundation for parents to enhance their linguistic interactions with their children. Specifically, the initiative teaches parents about three primary practices called "the 3Ts"—tune in, talk more, and take turns—mirroring scientific findings that parental responsiveness, quantity of language input, and quality of communication interaction, respectively, are all integral to language development. The TMW program was born out of a small randomized controlled pilot study, which found that the intervention significantly increased parents' knowledge about how their language input scaffolds their child's language development. Moreover, parents' linguistic interactions with their children also significantly increased during the intervention, measured in part both by adult word count and by conversational turn count. Importantly, although behavioral changes were observed only in the short term (that is, during the intervention), parents' increased knowledge of child development persisted for several months after the intervention ended.

Because parents' own knowledge of child development is a critical predictor of their linguistic interactions with their children and may partially mediate the relationship between a family's SES and the quantity of child-directed speech, many interventions target parents' knowledge to increase their language input. In one such recent study, researchers at the University of Washington conducted a randomized controlled trial to evaluate the effects of a parent coaching intervention among infants aged six to 14 months. The researchers used LENA recordings; parents in the intervention group received individual coaching appointments to get feedback, listen to their own language input recordings, and discuss age-appropriate activities that promote language growth. Results showed that the intervention increased infant-appropriate language use and parent-child turn-taking, and that both variables were significantly correlated with children's language growth and outcomes at 18 months. Although sustaining parental post-intervention behavior change is a persistent challenge throughout intervention work, the success of such parent-directed language interventions demonstrates that increasing parents' knowledge of child development and targeting social aspects of home language input can notably improve children's developmental outcomes.

Beyond such small-scale studies, researchers have conceived population-level public health prevention and intervention approaches to improving the early home language environment. The first such initiative, *Providence Talks*, was launched in 2013 in Providence, RI, and gave families LENA devices along with coaching. Among families participating in the citywide pilot who completed at least four coaching sessions, the quantity of language spoken in the home increased by nearly 10 percent. The pilot also found that families who started out at the lowest word count level made the most significant progress, increasing words spoken in the home by 50 percent. Since then, five more cities were selected to replicate the government-led initiative, launching interventions including *Say and Play with Words* in Louisville, KY, and *313 Speaks* in Detroit, MI.

Interventions that target parenting practices such as sensitivity and responsiveness have also furthered our understanding of how high-quality parent-child interactions support language development. Dozens of studies have documented the effectiveness of Play and Learning Strategies (PALS), an intervention that trains low-income mothers to respond to their infants' communication signals in a sensitive, warm, and contingent manner. One study of PALS showed that children in the intervention group had greater receptive vocabulary, initiated conversations more often, and produced more words during mother-child interactions, compared with children in the control group. Together, these findings suggest that responsive and engaging caregiver-child communication modulates the effects of adversity on child development.

Thus positive caregiving practices can be a protective factor against adversity, though researchers need to identify further how such protective factors influence neural development. Yet few studies of interventions seeking to improve children's environments have included measures of brain structure or function. In one study of more than a hundred Head Start families, sessions to improve children's attention, when coupled with sessions to teach parents how to support children's attention and reduce family stress, led to enhanced brain function in preschoolers. In a large study of a program called Strong African American Families, black families from lower-SES backgrounds were randomly assigned to either a multisession intervention focused on parenting skills or a control group that only received information on children's development, stress management, and exercise. Among children in the control group, a longer period of living in poverty was associated with smaller brain volume in areas related to memory. But among children whose parents participated in the intervention, the duration of childhood poverty wasn't linked to brain structure, suggesting that the intervention mitigated poverty's harmful effects on neural development. Thus, prevention and intervention programs may ameliorate the damage that socioeconomic disadvantage can do to language and executive function skills at the neural level.

Although few studies have included technology-based solutions, such as mobile phones, smartphone applications, or game-play, an increasing number of interventions rely on mobile phones as a means to share information with caregivers and directly influence their

behavior. The evidence so far suggests that interventions delivered through mobile devices can impact health behaviors and may be able to support parents in activities that promote language development. For instance, a recent six-week intervention called the Parents and Children Together (PACT) program, administered via electronic tablet, relied on behavioral tools such as reminders, goal setting, and social rewards; low-income parents who participated more than doubled the amount of time spent reading to their three- to five-year-old children. Such *light-touch* interventions may produce behavioral change at a lower cost per child, compared with large-scale in-person interventions. Similarly, smartphone apps, such as one called Vroom, offer parents brain-building activities designed to be incorporated easily into daily routines. A recent study successfully used Vroom's "brain building moments" to encourage parents to think of daily opportunities for engaging their infants in increased language and social interactions. Though such platforms hold promise for promoting positive parenting behaviors and enhancing language outcomes, as of yet we have little evidence of their long-term efficacy.

The programs we've discussed represent first steps toward developing parent-directed interventions that could improve children's language learning trajectories, especially those of children in lower-SES homes. These programs demonstrate that parent-directed interventions can change home environments, at least in the short term. Though the ultimate goal is sustained parental behavior change and sustained positive impacts on child outcomes, the short-term results still provide cause for optimism, as the findings so far support the hypothesis that parental linguistic behavior is malleable.

Despite the success of initiatives aimed at harnessing the role of parents and caregivers in children's language development, several challenges persist. Most prominently, the limited follow-up and tracking in much of the research to date means that we lack a complete assessment of behavioral sustainability to show whether the changes we see in children in the short term translate into positive longer-term child outcomes. Additionally, we know little about whether particular aspects of interventions are more important than others for affecting behavioral change, or whether synergy among linguistic feedback, parental sensitivity, and parental education, among other factors, is needed for interventions to be effective. Although results suggest that it's easier to change parents' knowledge than parents' language behaviors, a long-term increase in parents' knowledge on its own isn't sufficient to create long-term behavior change—though it may be a good starting point. We must continue trying to improve children's early home language environment, especially among low-SES families that are vulnerable to compounding hardships of increased physical and psychosocial stress. Ultimately, parent-focused interventions have demonstrated promise by affecting behavior and neural change. Moreover, these interventions have shown that when parents are given the proper tools, insight into their own importance in their children's development, and support to help their children reach full potential, they are critical agents in changing their children's language learning trajectories.

Conclusions

Research clearly shows that the early home language environment, and parents in particular, form the foundation of children's language development. The integration of neuroscience with developmental psychology theories has helped us understand the long-lasting effects of how parents shape the home learning environment and how they communicate with their children. Research findings support a social-relational approach by which caregiver-child interactions—the most pervasive and potent relational experiences of childhood—can be seen as a primary mechanism behind experience-driven differences in children's neural development and academic readiness. In short, the way caregivers communicate with children affects children's developmental outcomes. Given the evidence that attuned and responsive care promotes optimal development, we need to explore the links between caregivers' interactions with children and children's subsequent brain development. Interventions promoting child language input must focus on talking, reading, and labeling objects and emotions early in life.

The policy and education sectors have made strides in promoting parents' reading and talking with school-age children; now we should further encourage such practices with infants and toddlers. When it comes to policy, it will be important to narrow socioeconomic-related differences in home learning environments—for instance, by making books, toys, and other learning materials more accessible in the home, beginning in infancy. Other supports could include large-scale parent education programs and advocacy interventions through platforms that families already interact with, including primary care, early childcare, and home visiting. Such programs could further impart the message that parents construct a child's home learning environment and are therefore the principal agents of developmental change in their children's lives.

Endnotes

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