CHAPTER 2

Early Environmental Influences on Language

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The science of early literacy begins with language. A large body of literature documents clear associations between young children's oral language skills and their literacy development (Justice & Jiang, Chapter 11, this volume). Decoding skills are also essential for literacy but need to be explicitly taught starting in the preschool years. Oral language skills, on the other hand, develop from birth, and are highly influenced by environmental experiences. We use the term *oral language skills* broadly to refer to the various components of language that children acquire over the first 5 years, including phonology, vocabulary, syntax, and pragmatic skills. In this chapter we provide a brief overview of the research on environmental influences on oral language development, with a specific focus on the important role of language input during social interactions. Our review is limited primarily to typically developing children learning a first language. After summarizing the literature, we highlight some of our recent work in this area and suggest directions for future research and implications for intervention and instruction.

Background

Infants Need Social Interaction to Learn a Language

Infants need to be exposed to language used around them to learn language, and it is essential that this input is social. The *social gating hypothesis* (e.g., Kuhl, 2007) highlights how the infant brain benefits from contingent social interaction early in life for language learning. As an example, one study revealed that American infants who were exposed to Mandarin in a series of book-reading sessions with a live Mandarin-speaking woman reading the books with them were able to learn how to discriminate different phonemes in Mandarin. However, a separate group of American infants who were exposed to only a video of the same woman reading the same books in Mandarin did not learn to discriminate the sounds. Thus, it is not just the input that is necessary for phonological development in infancy, but the contingent social interaction that comes along with the input (Kuhl, 2010). Research with toddlers found similar results in which children were able to learn new verbs when interacting with a live experimenter or an experimenter in a contingent interaction over Skype; however, when watching and listening to the same input on a yoked video, they did not learn the new verbs (Roseberry, Hirsh-Pasek, & Golinkoff, 2014). However, beginning later in the second year of life, once children's cognitive and language skills increase, they become able to learn from nonsocial input, such as video, and from overheard speech spoken to others (e.g., Akhtar, 2005). Yet despite these increasing skills, research suggests that toddlers continue to benefit most from speech used in contingent back-and-forth social interactions (Hirsh-Pasek et al., 2015).

Input and Vocabulary Development

Young, preliterate children need to hear words to learn those words. While there is experimental evidence that children can pick up words relatively quickly from single exposures (e.g., Carey & Bartlett, 1978), research on everyday parent–child interactions shows a developmental progression where in infancy there is a positive association between repetition in the input and later vocabulary size (Newman, Rowe, & Ratner, 2016), yet in toddlerhood it is diversity in the input that is associated with vocabulary growth (e.g., Rowe, 2012). In infancy, children are also more likely to learn words if they are used to label objects in the child's line of attention (Yu & Smith, 2012), for example, labeling the "shoe" while the child is looking at the shoe. Relatedly, toddlers learn more when language is used during episodes of joint attention in which caregiver and child are jointly interacting around a shared focus than from language used outside of joint attention episodes (Tomasello & Farrar, 1986), echoing the importance of contingent social interaction discussed earlier. Preschoolers, with their more advanced cognitive and language skills, benefit from contingent conversations that are more challenging, in that they have an abstract focus (talking about future plans or why dinosaurs are extinct) than those that are more grounded in there here-and-now (e.g., Rowe, 2012). Indeed, experience with these types of decontextualized conversations in early childhood is associated with kindergarten vocabulary, syntax, and narrative skills, as well as academic language skills in adolescence (e.g., Demir, Rowe, Heller, Goldin-Meadow, & Levine, 2015; Uccelli, Demir-Lira, Rowe, Levine, & Goldin-Meadow, 2019). Thus, across early development, children of all ages benefit from contingent back-and-forth interactions, yet the complexity of the linguistic input should increase with age, as well as the abstractness of the topic of conversation (e.g., Rowe & Snow, 2020).

Syntactic Exposure and Development

While syntactic development follows a relatively predictable course in early childhood, children do vary widely in their syntactic skills at any given age (e.g., Fenson et al., 1994) and language exposure still plays an important role. For example, exposure to verbs used in diverse sentence frames is found to support learning of those verbs (e.g., Naigles & Hoff-Ginsberg, 1995). More generally, children who are exposed to input that is more syntactically complex and contains more diverse syntactic structures have faster growth over time in their own productive syntax as measured by the mean length of utterances (MLU) produced (Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010). Parents who use a larger proportion of complex sentences when interacting with their preschool-age children have children who use a larger proportion of complex sentences in those same interactions and perform better on a separate syntax comprehension assessment (Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002). In addition, preschool children in classrooms with teachers who use a larger proportion of complex sentences have greater increases over the course of the school year in their syntactic comprehension (Huttenlocher et al., 2002). This finding is important, because it rules out any potential genetic confounds, as the teachers are not related to the children. Thus, exposure to a variety of syntactic structures in the input is positively associated with children's understanding of and use of those structures.

There is some evidence from short-term interventions that the relationship is causal. For example, use of passive sentences is relatively rare in day-to-day input in English speaking families (e.g., Maratsos, Fox, Becker, & Chalkley, 1985), and passives prove challenging for children to comprehend. To test out whether increased exposure to the passive voice in the input would promote syntactic development, Vasilyeva, Huttenlocher, and Waterfall (2006) developed a book-reading intervention in which they inserted passive sentences into books, then tested whether regular exposure to the passive stories (compared to the active stories) over a short period of time would influence children's comprehension of passive sentences on a separate assessment. Indeed, they found significant positive increases in passive understanding for the children in the passive book condition, suggesting that increasing exposure to certain syntactic constructions can cause an increase in understanding of those constructions (Vasilyeva et al., 2006).

Environmental Influences on Pragmatic Development

Pragmatic development includes the ability to use language socially to convey different intents, such as to pose a question or issue a command, and to use language appropriately given the situation, which often requires understanding the

perspective of a conversational partner. Children as young as 9 months of age are found to understand the communicative intentions of others (Stephens & Matthews, 2014), and beginning in infancy, through their uses of gesture, children produce different intents such as "to give" or "to direct attention" or "to provide information" (Bates, Camaioni, & Volterra, 1975; Liszkowski, Carpenter, & Tomasello, 2008). Across early childhood there is large variation in children's pragmatic development that is associated with, but distinct from, variation in other facets of language development such as vocabulary and syntax (O'Neill, 2007). Studies looking at caregiver uses of communicative intents with children suggest that parents use a limited range of intents with infants (i.e., directing attention, discussing joint focus of attention), and similar to lexical and syntactic input, they increase in the diversity and sophistication of communicative intents produced as children age and increase in language ability (Pan, Imbens-Baily, Winner, & Snow, 1996). However, we do not have much literature on the environmental factors that contribute to variation in pragmatic development or on the specific pragmatic skills that are most relevant for later outcomes (e.g., Matthews, Biney, & Abbott-Smith, 2018). Nonetheless, there are studies showing that engaging in certain types of communicative acts/interchanges with children promotes language development more broadly. For example, positive associations are found between parents' use of conversation-eliciting utterances, such as wh-questions, and toddler's language (e.g., Rowe, Leech, & Cabrera, 2017), whereas negative associations are noted between parents' use of utterances to direct their child's behavior and language learning (e.g., Rowe, Coker, & Pan, 2004; Tomasello & Todd, 1983). Taken together, the findings are consistent with the notion that using language in a way that helps to engage children in extended back-and-forth conversations on more and more abstract topics as they age is beneficial for developing conversational skill and language development more broadly (Rowe & Snow, 2020; Tomasello, 1988).

Why Do Home Language Environments Vary So Much?

In line with sociocultural theory (e.g., Bruner, 1983; Vygotsky, 1978), the previous review demonstrates how social interaction is at the core of language development and that variation in children's language exposure predicts variation in language development. This leads to an important follow-up question: What factors contribute to this variation in language environments? Indeed, myriad factors play a role, including socioeconomic status (SES; often measured as parental income and/or education level), literacy skills, and knowledge of child development, each of which positively relates to the amount and diversity of parent communication with children (e.g., Hart & Risley, 1995; Leung & Suskind, 2020; Rowe, 2008; Rowe, Pan, & Ayoub, 2005). On the other hand, factors such as maternal stress, depression, financial hardship, and household chaos are typically negatively associated with features of parent input found to promote language learning (e.g., Ellwood-Lowe, Foushee, & Srinivasan, 2022; Evans, Maxwell, & Hart, 1999; Kaplan, Danko, & Diaz, 2010; Rowe et al., 2005). Furthermore, whether the parents are bilingual and their beliefs about bilingualism affect the extent to which children are exposed to one or more languages at home and school (Surrain, 2021). For more on language exposure and bilingual development, a topic beyond the scope of this chapter, see Hoff (2018) for a review. (For more on language and literacy development in dual language learners, see Mancilla-Martinez, Chapter 3, and Phillips Galloway & Lesaux, Chapter 24, this volume.)

Summary

In summary, the research on parent input and child language development highlights the importance of frequently engaging children in back-and-forth extended conversations on topics of interest to them. Given these findings, our recent work has focused on (1) trying to better understand the mechanisms underlying the relationship between language exposure and language development, and (2) determining whether parent input is malleable through intervention, and if so, whether changes in input cause changes in children's language development. We present some of our recent findings in each of these areas in the following section.

Building on the Research to Understand Neural Mechanisms and Causal Intervention Effects

Neurodevelopmental Mechanisms

Children's observable language development is supported by the development of a complex neu-

robiological network that spans all four lobes of the cerebral cortex (for review, see Friederici, 2006). Current evidence overwhelmingly supports a gene × environment theory of brain development, whereby a child's genetics provide the blueprint for neural development, yet the child's early experiences shape individual differences in neural development (Boyce, Sokolowski, & Robinson, 2020). Indeed, the developing brain is remarkably plastic, and children's early experiences—both favorable and adverse—influence developmental trajectories of both brain structure and function, through a process called "biological embedding" (Gabard-Durnam & McLaughlin, 2020). A core topic of neurodevelopmental investigation is how early experiences become biologically embedded, and how these brain changes in turn influence cognitive and behavioral development. Specifically, for children's language exposure to influence their language development, presumably this must be mediated by one or more neurodevelopmental mechanisms (Noble, Houston, Kan, & Sowell, 2012; Perkins, Finegood, & Swain, 2013). Guided by theories of biological embedding, we recently investigated these mechanisms in a series of magnetic resonance imaging (MRI) studies aimed at understanding relationships between SES, language exposure, and cognitive and brain development.

While most early studies of language exposure relied on hand-coding of videotaped parent–child interactions, typically, in a laboratory setting or in short home recordings, an increasing number of studies utilize LENA (Language ENvironment Analysis)—a small, 2-ounce recorder worn in a child's shirt pocket that records full days of the child's firsthand auditory experience (Gilkerson et al., 2017). LENA software analyzes children's auditory environments, segments the speech, and estimates how many words the child heard spoken by an adult within earshot ("adult word count"), how many utterances were spoken by the child wearing the recorder ("child vocalization count"), and how many back-and-forth conversational turns occurred between the child and any adult with no more than 5 seconds pause ("conversational turn count"). A SES-diverse sample of families with children ages 4–6 years completed 2 days of LENA recordings, as well as lab-based measures of language skills and brain development.

Higher parental education and family income were associated with greater numbers of adult words and conversational turns (Romeo, Leonard, et al., 2018; Romeo, Segaran et al., 2018), consistent with several earlier studies of SES and language experience (e.g., Rowe, 2018). SES was also positively correlated with children's language skills (a composite of receptive and expressive vocabulary and morphosyntax). However, after controlling for SES, conversational turns continued to predict unique variance in children's verbal scores, and significantly mediated the relationship between SES and children's verbal scores (Romeo, Leonard, et al., 2018; Romeo, Segaran, et al., 2018). No such relationships were found with adult word count, suggesting that after accounting for socioeconomic variance, conversational experience is more strongly linked to language development than the sheer number of words heard.

Turn-taking experience was also associated with measures of children's brain function and structure. Using functional MRI (fMRI), children's brain activation was measured during a story-listening task that indexes language comprehension (Romeo, Leonard, et al., 2018). Higher conversational turn experience was correlated with greater activation in Broca's area, a region of the left inferior frontal gyrus known to be involved in speech and language processing. Additionally, diffusion-weighted imaging (DWI) indexed the structural connectivity of white-matter tracts between brain regions. Children who experienced more conversational turns also exhibited greater fractional anisotropy—a measure of white-matter integrity and maturity—in the left arcuate and superior longitudinal fasciculi, which connect Broca's area to other language regions in the brain development (Romeo, Segaran, et al., 2018). Each of these neural measures independently mediated the relationship between conversational turns and language scores, indicating both a functional and structural mechanism linking language experience to language skill.

A partially overlapping sample of children from the cross-sectional study also participated in a longitudinal examination of neural plasticity in response to modifications to the language environment. Families were randomly assigned either to a control group or to attend a 9-week family-based intervention designed to increase parent–child communication through "meaningFULL," responsive, and balanced language use (Neville et al., 2013). On average, families who completed the intervention showed greater

increases in conversational turns but no changes in the overall number of adult words or child vocalizations (Romeo et al., 2021). Furthermore, the magnitude of change in conversational turns was positively correlated with longitudinal cortical thickening in two regions: a large part of left inferior frontal gyrus, including Broca's area, as well as prefrontal regions known to be involved in executive functioning (Diamond, 2013; Miller & Cohen, 2001), and the left supramarginal gyrus, a part of the parietal lobe that is known to subserve language comprehension, phonological processing, and social cognition (Tremblay & Dick, 2016; Oberhuber et al., 2016; Adolphs, 2009). Finally, growth the in the supramarginal region mediated the relationships between changes in turn taking and children's language development (Romeo et al., 2021). This indicates that conversational turns support language development through cortical growth in language and social processing regions, and suggests that socially motivated verbal interaction, rather than passive language exposure, best supports brain and language growth.

Parent-Focused Interventions

Intervention designs are especially important in language research for theoretical and practical reasons. From a theoretical perspective, such designs help to establish causal effects of caregiver input, because one can test whether the intervention—focused on only parents—leads to improved child outcomes. From a practical standpoint, conversational interventions hold promise for large-scale implementation because they do not involve expensive materials, rather revolving around enhancing existing conversation practices in the home. Recently we have developed several light-touch interventions of this sort to improve child language by intervening around socially contingent caregiver–child interactions (Leech, Wei, Harring, & Rowe, 2018; Leech & Rowe, 2020; Rowe & Leech, 2019). In these studies, parents receive information about the importance of conversations for oral language skills and strategies for how to engage in these conversations. The theory of change associated with these interventions is that increasing parent knowledge may change the home language environment and in turn improve children's developing oral language capacities. This theory of change is based on work showing that parents who are more knowledgeable about child development and developmental milestones engage in parenting practices that are more promotive of children's language and cognitive development (Garrett-Peters et al., 2008; Leung & Suskind, 2020; Miller, 1998; Rowe, 2008).

In one intervention study (Leech et al., 2018), we sought to increase abstract conversations between parents and preschoolers. As discussed earlier, preschoolers' oral language skills benefit from caregiver input, which challenges them to think and discuss abstract, nonpresent concepts. We refer to these conversations as *decontextualized language* (Snow, 1991), which may include discussions about the past or future, explanations and definitions of new words, or engagement in pretense. Decontextualized language is a particularly appealing focus for intervention, because parents already use this type of language with their children and it can be embedded in many routines such as play or mealtimes, the latter of which was the focus of this study (Beals, 1993, 2001).

Because asking parents to increase their decontextualized talk is a rather opaque message to communicate, we devised an acronym called READY Talk to provide parents with examples of decontextualized talk in an accessible framework. Each letter of READY stood for a different type of decontextualized language (*R*ecall past events, *E*xplain new words and concepts, *A*sk lots of questions, *D*iscuss the future), and a message to increase parents' motivation and efficacy (*Y*ou can make a difference in your child's academic success). To test the effectiveness of the READY Talk program, 36 higher-SES parents of 4-year-old children were randomly assigned to receive the program or to a control condition. Parents assigned to the intervention condition watched a 15-minute video, which consisted of an introduction to READY Talk and video models of dyads using each type of READY Talk. All parents then recorded one mealtime conversation per week for the following month (four recordings in total), which we transcribed and coded for decontextualized language.

Findings indicated that parents who received the intervention used more than twice as much decontextualized language during home mealtimes than parents in the control condition. Intervention effects were maintained across the study; at the final recording intervention parents' decontextualized talk comprised 49.1% of their total utterances versus 18.9% in the control condition. Parents who received the interven-

tion also increased other forms of decontextualized language not covered in the READY Talk program (e.g., scripts, connections between the present and nonpresent), suggesting that parents understood READY Talk as a broad style of conversation. Critically, children of intervention parents used significantly more decontextualized language than children of control parents (42.1 vs. 13.9% of utterances). This is especially important, because preschoolers' own use of decontextualized language is predictive of future academic language abilities (Uccelli et al., 2019).

In a follow-up analysis with the same sample of families, we investigated whether the READY Talk intervention also increased the quantity and quality of conversational turn taking (Leech & Rowe, 2020). We hypothesized that the abstract focus of decontextualized conversation would require extended utterances to ensure the message is clear to conversational partners (Curenton & Justice, 2004; Demir et al., 2015; Snow & Uccelli, 2009; Westby, 1991). Transcripts were processed manually to yield the number of conversational turns ("turn-taking quantity") and measures of "turn-taking quality": whether the turn contained decontextualized language, and each turn's mean length of utterance, vocabulary diversity, and total number of words. Consistent with our predictions, intervention parents increased the quantity of their turn taking compared to control parents. Importantly, there were also effects on the quality of turn taking such that conversational turns in the intervention condition contained more decontextualized references and greater vocabulary diversity. These findings illustrate that encouraging parents to incorporate decontextualized language into their everyday conversation leads to an increase in the types of socially contingent interactions that support preschoolers' oral language and school readiness skills.

Future Directions

Based on our current knowledge of environmental effects on language, we suggest that future empirical research dig deeper in three areas. First, a continued effort to uncover the specific features of caregiver communication and social situations that optimize learning across early development is helpful, as we can build on this work in later design of parent or classroom interventions. Second, additional research on mechanisms, both neural and behavioral, that contribute to young children's language learning will also help inform our understanding of the language-learning process and efforts to maximize environments for learning. Finally, we know that context plays a large role in shaping children's language environments and language learning (e.g., Rowe & Weisleder, 2020). Thus, it is increasingly important to gain a greater understanding of the cultural-, societal-, and individual-level factors that lead to variation in young children's language environments, and to determine the extent to which children in different populations benefit from similar or different environmental factors.

In terms of implications for intervention, we encourage further testing of programs designed to promote contingent conversations between caregivers and young children. The majority of parent-focused intervention research has been with parents of children at risk for language impairment. In this population, several meta-analyses show general positive effects of parent-focused interventions on children's language development (e.g., Roberts, Curtis, Sone, & Hampton, 2019; Roberts & Kaiser, 2011). Interventions with low-SES families in which children may be at risk for slower language development due to environmental factors have also recently shown positive effects on parent input and child vocabulary growth (Heidlage et al., 2020; Leung, Hernandez, & Suskind, 2020), yet we have less research in this area and more evidence is needed. Furthermore, now that technological advances are providing opportunities to reach parents via different modalities, a greater understanding of the role of technology in delivering parent interventions would be useful. Finally, we know that intervention effects can differ for different families (e.g., Rowe & Leech, 2019). Thus, further understanding of what types of parent-focused interventions work or don't work for parents with different characteristics (i.e., growth mindsets, depression) will help in adapting intervention delivery.

Finally, while much of the research reviewed in this chapter is from parent–child interactions at home, there are parallel implications for instruction. First and foremost, teachers should understand that children are going to arrive in their classrooms with diverse home language experiences and language skills. Maximizing opportunities for children to engage in extended conversations in classrooms is just as important

as it is in home environments. Indeed, one study of the language use in a single classroom of 2- to 3-year-olds from low-SES backgrounds found that those children who engaged in more conversational turns in the classroom over the course of the year increased the most in their language development (Perry et al., 2018). Teachers can take advantage of this literature on caregiver input to optimize the language environments of their classrooms by exposing children to diverse vocabulary, complex syntax, and opportunities to engage in extended and abstract conversations.

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