13 Key Issues and Future Directions: How Do Children Acquire Language?

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In part II, the authors have provided a clear overview of some of the key findings in language acquisition research, and the theories that have been proposed to explain them. The section covers a wide range of topics. It starts with how children learn to interpret and reproduce speech (Johnson & White, chapter 8) and then explores how they learn to map words to meanings (Kucker, chapter 9) and put words and morphemes together into grammatical sentences (Allen & Behrens, chapter 10). Skeide (chapter 11) then outlines how all these learning tasks might be mapped to structural networks in the developing brain, and Chondrogianni (chapter 12) discusses the questions that arise when we consider how children learn more than one language at a time. From this overview, it is immediately apparent that research in language acquisition covers many topics and that it crosses the disciplinary boundaries between developmental psychology, linguistics, and neuroscience. Despite this diversity, some common themes emerge, which we summarize here.

The clearest theme that emerges is the complexity of the task facing language learning children. They have to acquire a language-specific phonemic inventory, segment a continuous speech stream to identify words (Johnson & White), and map words onto meanings (Kucker). They must then extract abstract, hierarchical, grammatical patterns from a linear input that provides only indirect evidence for grammatical rules and learn a complex set of discourse-pragmatic cues that govern referential choice (Allen & Behrens). Yet almost all children achieve this in early childhood, despite extremely variable input from child to child, and multilingual children achieve it for two or more languages simultaneously (Chondrogianni).

Each new language advance builds on a basic foundation of previous learning. For example, once infants learn some language-specific properties of speech (e.g., phonemes, dominant stress patterns), they can begin to segment their input (e.g., via attention to distributional information, see Johnson & White). Successful segmentation of the input allows infants to recognize, and store, the phonetic detail of words as independent units, which enables them to start to map words onto meaning (Kucker). Mapping words onto meaning is, in turn, the first step toward the discovery of morphology and syntax (Allen & Behrens). However, this does not mean that language acquisition is necessarily stagelike because it is not essential to complete the acquisition process for a precursor skill before progressing to the next learning task. Instead, it seems that "infants are learning about their language at multiple levels in parallel" (Johnson & White, p. 108) and that different subsystems interact throughout the acquisition process. For example, English-speaking children probably need only acquire a few content words before they learn the dominant trochaic stress pattern (Cutler & Carter, 1987) that they can then start to use as a cue for segmenting further words from the speech stream. Such interactions appear to be present across the whole system. For instance, Skeide presents neuroimaging data to suggest that the hemodynamic activity supporting semantic and syntactic processing are largely overlapping before the age of seven years (Brauer & Friederici, 2007; Nunez et al., 2011). Additionally, Chondrogianni discusses how bilingual children often experience crosslinguistic transfer when acquiring aspects of syntax that are discourse-conditioned (e.g., subject expression).

A second theme that emerges concerns the nature of the learning mechanisms. Given the complex and dynamic nature of the system, there must be multiple, powerful learning mechanisms in the developing brain for language acquisition to occur. We say mechanisms (plural) rather than mechanism (singular), because learning involves solving a number of different tasks and thus is bound to require more than one type of learning mechanism. However, as we have seen in the chapters in this part, there are still fierce debates about what these mechanisms are. We suggest that at least three different types of mechanism will turn out to be essential.

First, children must be able to process language online; what Kucker calls "the real-time/in the moment reaction" (p. 114) (i.e., *realizing that wif is the coffee mug*). We can only acquire a language if we are able to process incoming input, and identify, at some level, the meaning that the speaker is trying to convey. Thus, we will need a mapping mechanism that integrates cues from the stimuli ("in the moment") to map the speech signal to the correct meaning. Discussions of this online mapping process are most prevalent in the word-learning literature, for example, to integrate speech, visual, and sociopragmatic cues to map words to correct referents (Kucker). However, online processing is equally important to other language-learning tasks, such as identifying when a minimal pair of phonemes marks a semantic distinction (for instance, in the Italian *capello* 'hair' vs. *cappello* 'hat'), identifying word-order constraints on meaning (e.g., that the sentence *the girl kissed the boy* refers to the action that a girl is bestowing on a boy), or integrating discourse level cues to interpret morphosyntactic cues. Thus, the ability to process language rapidly is an essential component of the acquisition process, even if children sometimes do it imperfectly (e.g., five-year-olds tend to misinterpret temporarily ambiguous garden path sentences such as *Put the frog on the napkin in the box*; Trueswell, Sekerina, Hill, & Logrip, 1999; see Allen & Behrens, section 4.4).

However, online processing is not enough. A second mechanism is required: children need to be able to store particular instances of language use in long-term memory for later retrieval. As Kucker states, this may well involve separable mechanisms: "Mapping is a real-time process serving communication in-the-moment. Learning, on the other hand, … is better served through a longer process of strengthening (and weakening) word-referent associations" (p. 114). No doubt the long-term storage of information aids rapid online processing; for instance, having more robust phonemic knowledge allows better recognition of allophonic variants of phonemes and better segmentation of the input (Johnson & White), and knowledge of frequent frames may enable the identification of syntactic categories (Allen & Behrens).

Third, children need to be able to consolidate the information they have retained and generalize over particular instances of knowledge to build categories. For example, they must learn to generalize the word *dog* to all types of dogs (big dogs, small dogs, dogs in books, dogs on the TV) while excluding all other animals from the dog category (Kucker). They must learn to categorize words into grammatical categories (nouns, verbs, adjectives, etc.) and to generalize across particular instances of a category (e.g., nouns) to extract morphological markers (e.g., the English plural morpheme *-s*; Allen & Behrens). Some of these tasks may require a mechanism that accumulates information slowly over time (e.g., via associative learning processes; McMurray, Horst, & Samuelson, 2012), whereas others may rely on an error-based, prediction mechanism (Chang, Dell, & Bock, 2006) or hypothesis-driven learning (Medina, Snedeker, Trueswell, & Gleitman, 2011). Some of these mechanisms, such as those that are sensitive to prosodic information (Perani et al., 2011), may rely solely on low level, automatic processing whereas others, such as the emergence of semantic and syntactic representations at the sentence level, may need higher level processing involving further analysis by more complex mechanisms (Skeide). Some processes may even rely on memory consolidation during sleep. For example, in nine-month-old infants, lexical-semantic learning seems to be dependent on the consolidation of recent episodic memory traces during sleep (Friedrich, Wilhelm, Born, & Friederici, 2015; see Skeide). All these mechanisms will need to be capable of learning two or more languages simultaneously; for instance, to learn to use cues such as rhythm (stress/syllable timed languages) to distinguish between languages or to learn to discriminate between phonetic units belonging to the two languages (Chondrogianni).

Another clear point of commonality across the chapters is the fact that the learning mechanisms must be constrained or biased to use the input in certain ways. As Saffran has stated, "learners must be able to detect input statistics that are pertinent to linguistic structure amid all the irrelevant information in the input" (2002: 173), and to do this, the mechanisms must be biased to pay attention to some regularities in the input and not others. The debate about what kinds of constraints must be built into our learning mechanisms has been one of the most fiercely argued in the history of language acquisition research. It can be tracked back nearly 60 years to Chomksy's 1959 review of Skinner's book *Verbal Behavior*, which argued that behaviorist learning processes were incapable of learning a higher order cognitive function such as language. Since then, we have engaged in a long, productive debate about whether low-level domain-general cognitive constraints are sufficient for learning or whether innate knowledge of complex, abstract linguistic principles is required (see Allen & Behrens). However, this literature has, perhaps, focused too narrowly on these two, polar opposites. Instead, it is likely that the learning mechanism is constrained on a number of different levels.

Candidate low-level constraints include physical constraints (the binding of an object and word in physical space; see Kucker), as well as statistical biases; for example, frequent (Johnson & White), reliable (Allen & Behrens), or perceptually salient (Johnson & White) statistical cues may be weighted more highly (Bates & MacWhinney, 1987). There may also be higher-order constraints such as sociopragmatic cues (Kucker), as well as language-specific cues such as auditory biases (Skeide), phonological constraints (Johnson & White), constraints on the form of possible words (Johnson & White), or word-meaning mapping biases such as mutual exclusivity (Kucker). Sensitivity to some of these constraints may be built into the learning architecture by the genetic code, but others, such as mutual exclusivity, are likely to be a product of learning themselves (Halberda, 2003). Some tasks may need more powerful innate linguistic knowledge to constrain learning (e.g., language-specific knowledge about syntactic categories and roles; Allen & Behrens), although this is still a highly controversial proposal (see Ambridge, Pine, & Lieven, 2014, including commentaries).

To date, the field has also not paid enough attention to the fact that children's learning strategies are highly likely to change with age. For example, substantial evidence now suggests that referential mapping strategies change with development, with two-year-olds relying more on social cues, perceptual salience, and cross-modal synchrony and older children relying more on grammatical cues (Johnson & White; Kucker). Similarly, children can detect grammatical case marking cues by three years of age but may not be able to use this information to determine who is doing what to whom in a sentence until six years of age (Schipke, Friederici, & Oberecker, 2011; see Skeide). Some of these changes may be driven by the child's increasing knowledge of the world and of their language. For example, it is likely that the shape bias, which biases children to extend novel noun labels to similarly shaped objects, is learned through experience of how object labels tend to be extended (Kucker). Similarly, two-year-olds' ability to use abstract syntactic relations to comprehend novel transitive sentences seems to rely on the size of their vocabulary (Matthews, Lieven, Theakston, & Tomasello, 2007; see Allen & Behrens). However, others may wait upon the maturation of the necessary connections in the brain (Skeide). It is also highly likely that the developmental pattern is different in critical ways in multilingual children. For example, Chondrogianni summarizes work showing that bilingual children do not seem to develop a mutual exclusivity bias, or at least develop a much more context-dependent one, and that in second language (L2) learners, there may be delayed or different patterns of acquisition dependent on the characteristics of the L1 and its similarity to their L2. Much more work needs to be done to determine how the learning process itself changes throughout development, particularly in the field of developmental neuroscience, where we need to understand more about how the neural circuits change with age and with the accumulation of new knowledge. What is clear, however, is that only a developmentally dynamic model of language acquisition will be able to adequately capture the learning process.

Another theme we extract from this part concerns methodology. In the last few decades, language acquisition research has been revolutionized by methodological advances that have opened up new avenues of research, as well as making old methods much easier to implement. Noninvasive electroencephalography and eye tracking provide implicit measures of online language processing, enabling us to develop hypotheses about language acquisition in prelinguistic infants. Headturn preference and habituation methodologies allow us to determine what one-month-, -week- or even -day-old infants are able to discriminate (individual difference notwithstanding; e.g., Junge, Kooijman, Hagoort, & Cutler, 2012). New recording technology makes it easier for us to track and analyze how children use language in their natural environment and enables us to perform detailed analyses of the linguistic environment in which they are immersed. Even the more traditional methods (e.g., elicitation, forced-choice pointing) are easier to implement, and the data easier to analyze, with new presentation software and statistical programs. More advances are on the horizon, including techniques to make functional MRI and magnetoencephalography scanning easier with young children, open source tools for (semi)automatic transcription and coding of naturalistic data, and virtual reality labs in which we can create controlled three-dimensional learning environments for our experiments.

However, new methods bring new challenges as well as opportunities. First, there is the problem of integrating results from different methodologies. For example, what are we to make of the fact that six-month-olds look longer at a picture of their mom when they hear *mommy* and look longer at a picture of their dad when they hear *daddy* in a classic preferential looking design (Tincoff & Jusczyk, 1999; see Johnson & White)? Does this mean that these children have the same referential understanding of the words mommy and daddy as adults, or, as Johnson and White speculate, do they "simply associate labels and objects or events, in the way we might associate the bell of an ice cream truck with a delicious treat" (p. 103)? If the latter, how does this early type of understanding develop into the adultlike concept? Similar issues arise when we consider artificial language learning studies, where infants are trained on novel languages in the lab. For example, infants can learn to recognize word boundaries using transitional probabilities in artificial language experiments in which each "word" is three syllables long but cannot do it when the words are of a more naturalistic variable length (Johnson & Tyler, 2010; see Johnson & White). There are big questions still to be asked about how children use cues to language in the real, messy, complex world to develop adultlike linguistic representations.

Finally, we suggest that there needs to be more research on individual differences in future. Many of the findings cited in this part are based on between-subjects group-based experiments, which mirror the focus of research in language acquisition in general. However, there are large and stable individual differences both in children's environments, and in the sequence and speed of children's acquisition, which will need to be explained by any complete theory of language development (Kidd, Donnelly, & Christiansen, 2018). The quality and quantity of the language in children's environment clearly plays a role, both in monolingual and multilingual acquisition. However, other factors may be equally important, such as the speed with which children process linguistic information (Marchman & Fernald, 2008). Unfortunately, however, most of our current methodological designs simply measure group effects, which means they are often not sensitive enough to capture individual variation. Adapting these measures will require some thought; we will almost certainly need to test larger sample sizes, we will need to design our stimuli so as to maximize individual variation across children, and we will need to implement test-retest procedures to determine how much of the variation is meaningful and how much due to factors beyond our control, such as the infant's willingness to cooperate at the time of testing. This may not be a simple task.

In this chapter we have summarized some of the common themes that emerged in part II and highlighted what we think are the most promising directions for future research. The discussion demonstrates the complexity of the learning task, which requires that children master a number of different skills. The development of such skills relies on a strong basic foundation from previous learning, but this does not mean that acquisition is necessarily stagelike; instead, children are tackling many of the different tasks involved in parallel. The complexity of the learning task also requires that we posit multiple powerful learning mechanisms in the child's developing brain. Unfortunately, we do not yet know enough about what these mechanisms are or what constraints are built in that enable them to extract the relevant information from the input. We also do not know how children's learning strategies change over development, as the accumulation of knowledge, and the maturation of the brain, changes the nature of the learning task. In addition, although we already know a substantial amount about how different regions of the brain might support language learning, we need more work on how the brain builds the functional adult cortical language network. Finally, we have discussed the methodological advances that have made many of these insights possible and summarized some of the benefits, but also the challenges, that these advances bring to the study of language acquisition. In future, we will need to work to identify what the results from such studies tell us about the nature of children's developing linguistic representations, and we will need to learn how to adapt new methodologies to enable us to explore individual differences in acquisition.

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REFERENCES

Ambridge, B., Pine, J. M., & Lieven, E. V. M. (2014). Child language acquisition: Why universal grammar doesn't help. *Language*, *90*, e53–e90.

Bates, E., & MacWhinney, B. (1987). Competition, variation, and language learning. In B. MacWhinney (Ed.), *Mechanisms of language acquisition* (pp. 157–193). Hillsdale, NJ: Erlbaum.

Brauer, J., & Friederici, A. D. (2007). Functional neural networks of semantic and syntactic processes in the developing brain. *Journal of Cognitive Neuroscience*, *19*(10), 1609–1623.

Chang, F., Dell, G. S., & Bock, K. (2006). Becoming syntactic. *Psychological Review*, *113*(2), 234–272.

Chomsky, N. (1959). A review of B. F. Skinner's *Verbal Behavior. Language*, *35*(1), 26–58.

Cutler, A., & Carter, D. M. (1987). The predominance of strong initial syllables in the English vocabulary. *Computer Speech and Language*, *2*, 133–142.

Friedrich, M., Wilhelm, I., Born, J., & Friederici, A. D. (2015). Generalization of word meanings during infant sleep. *Nature Communications*, *6*, 6004.

Halberda, J. (2003). The development of a word-learning strategy. *Cognition*, *87*, B23–B34.

Johnson, E. K., & Tyler, M. D. (2010). Testing the limits of statistical learning for word segmentation. *Developmental Science*, *13*, 339–345.

Junge, C., Kooijman, V., Hagoort, P., & Cutler, A. (2012). Rapid recognition at 10 months as a predictor of language development. *Developmental Science*, *15*, 463–473.

Kidd, E., Donnelly, S., & Christiansen, M. H. (2018). Individual differences in language acquisition and processing. *Trends in Cognitive Sciences*, *22*(2), 154–169.

Marchman, V. A., & Fernald, A. (2008). Speed of word recognition and vocabulary knowledge in infancy predict cognitive and language outcomes in later childhood. *Developmental Science*, *11*, F9–F16.

Matthews, D., Lieven, E., Theakston, A., & Tomasello, M. (2007). French children's use and correction of weird word orders: A constructivist account. *Journal of Child Language*, *34*(2), 381–409.

McMurray, B., Horst, J. S., & Samuelson, L. K. (2012). Word learning emerges from the interaction of online referent selection and slow associative learning. *Psychological Review*, *119*(4), 831–877.

Medina, T. N., Snedeker, J., Trueswell, J. C., & Gleitman, L. R. (2011). How words can and cannot be learned by observation. *Proceedings of the National Academy of Sciences*, *108*(22), 9014–9019.

Nunez, S. C., Dapretto, M., Katzir, T., Starr, A., Bramen, J., Kan, E., … Sowell, E. R. (2011). fMRI of syntactic processing in typically developing children: Structural correlates in the inferior frontal gyrus. *Developmental Cognitive Neuroscience*, *1*(3), 313–323.

Perani, D., Saccuman, M. C., Scifo, P., Anwander, A., Spada, D., Baldoli, C., … Friederici, A. D. (2011). Neural language networks at birth. *Proceedings of the National Academy of Sciences*, *108*(38), 16056–16061.

Saffran J. R. (2002). Constraints on statistical language learning. *Journal of Memory and Language*, *47*, 172–196.

Schipke, C. S., Friederici, A. D., & Oberecker, R. (2011). Brain responses to case-marking violations in German preschool children. *Neuroreport*, *22*(16), 850–854.

Tincoff, R., & Jusczyk, P. W. (1999). Some beginnings of word comprehension in six-month-olds. *Psychological Science*, *10*, 172–175.

Trueswell, J., Sekerina, I., Hill, N., & Logrip, M. (1999). The kindergarten-path effect: Studying online sentence processing in young children. *Cognition*, *73*, 89–134.