How the Mind Grows from Conception to College

WELCOME TO YOUR CHILD'S BRAIN

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BLOOMSBURY
NEW YORK • BERLIN • LONDON • SYDNEY

Art credits:
Illustrations throughout by Lisa Haney, except as noted. Pages 12, 14, 19, 35, 92, 95, 102, 106, 114, 126, 157, and 223 by Patrick Lane. Pages 44, 116, and 203 by Sam Wang. Page 64 by Ken Britten. Page 86 ©iStockphoto/Daniel Rodriguez, modified by Ken Britten. Page 122 courtesy of Gordon Burghardt. Page 130 courtesy of Roger Tsien and Le Prix Nobel 2008.

Published by Bloomsbury USA, New York

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Library of Congress Cataloging-In-Publication Data has been applied for.

ISBN: 978-1-59691-649-4

First U.S. Edition 2011

3 5 7 9 10 8 6 4 2

Designed by Elizabeth Van Itallie
Printed in the U.S.A. by Quad/Graphics, Fairfield, Pennsylvania

Chapter 6

BORN LINGUISTS

AGES: BIRTH TO EIGHT YEARS

Complex skills require deep foundations. Babies start to learn language a long time before they are able to speak, preferentially focusing their attention on speech from birth—or even earlier, as hearing becomes functional during the third trimester of pregnancy (see chapter 11). Because babies do not have the motor abilities to express all the knowledge that they have obtained, though, you may not realize how much language they understand at a given age.

Newborn babies already prefer their mother's voice over other female voices, their native language over other languages, and speech over other sounds that have the same acoustic properties, including speech played backward. They can also detect a variety of vocal cues, including acoustic characteristics, stress patterns, and the rhythms of different languages. From early in life, your infant absorbs the huge amounts of information that will make him an expert in his native language, learning about its cadences, its sounds, the structures of its words, and the grammar of its sentences. As we discussed in chapter 3, most adults instinctively speak to infants in motherese, which is slower than normal language and contains exaggerated versions of consonant and vowel sounds.

Young infants can distinguish and categorize the sounds of all languages of the world, though adults often confuse the sounds of a foreign language. For example, the *r* and *l* of English sound the same to Japanese adults, but different to Japanese infants. As they acquire experience with speech, babies begin to specialize in the sounds (called *phonemes*) of their own language (or languages). By six months of age (for vowels) or ten months (for consonants), babies become better at identifying the phonemes of their native language and worse at identifying the phonemes of other languages. In other words, experience with language shapes

the categories into which babies place sounds, determining which variations in sound characteristics are meaningful (reflecting different phonemes) and which should be ignored (reflecting different speakers or other unimportant variations).

As we would expect, their neural activity reflects this phoneme learning. In older infants, the patterns of electrical signals in the brain recorded from electrodes on the scalp, termed *event-related potentials*, show that babies distinguish between a pair of sounds from the native language, while failing to distinguish two confusable foreign sounds. In younger infants, event-related potential patterns distinguish both foreign- and native-language sound pairs. This brain specialization is important for future language learning. Babies whose brains discriminate native sounds well (and foreign sounds poorly) at seven and a half months go on to learn language earlier than babies who show the less mature pattern of distinguishing all sounds equally well. The more discriminating babies learn words more quickly, produce more words and more complex sentences at twenty-four months, and produce longer phrases at thirty months than the less discriminating babies. So even though your baby isn't talking back, he is absorbing the patterns of your talk.

Social interaction is one cue that babies use to determine which sounds they should be learning. Nine-month-old infants who hear a brief tape recording or video of someone speaking a new language do not learn its sounds, but the same

amount of speech from a live person is sufficient to allow the babies to discriminate phonemes in the new language. (Under some circumstances, babies can learn from tape or video, but it takes longer than learning from a live person.) Indeed, certain measures of social interaction with a language teacher (including a parent) predict how well individual infants will remember the sounds of the new language. The preference for social interaction may be part of the reason that autistic children (see chapter 27), who do not interact well with other people (and do not prefer the sounds of motherese), have difficulty learning language.

The timing of speech production is determined by maturation of the brain regions that control movement. Forming understandable sounds requires considerable fine motor control and apparently a lot of practice. Babies first attempt to talk at around two months, when they begin cooing vowels, the least complicated speech sounds to produce. Some consonant sounds follow around five months, when babbling begins. Early babbling sounds the same in all babies, regardless of their native language. Around the end of the first year, babbling starts to include language-specific phonemes.

Responding with a comment or a touch to your baby's best attempts to communicate seems to encourage continued efforts to improve these skills.

Word learning also starts long before babies can produce words of their own. Six-month-old infants know their own names and will look at a picture of their *mommy* or *daddy* when they hear the word. As we discussed in chapter 1, infants can listen to a string of nonsense syllables and determine which of them are most commonly heard together as "words." They apply this talent to identifying words in normal speech, where words tend to run together without pauses. (To understand this phenomenon, think of the way a foreign language sounds; you can't guess where one word ends and the next begins.) Later, their brains learn about the regularities of sentence structure that constitute the rules of grammar in their native language. By nine months, familiar and unfamiliar words trigger noticeably different event-related potentials. By the first half of baby's second year, these potentials are different for words whose meaning

the child does or doesn't understand. Babies' brains also respond differently to made-up words depending on whether or not they obey the rules for which syllable should be stressed in the baby's native language. Stress patterns appear to be another tool that babies use to determine which groups of sounds are words.

In the second year, as children learn more words and become able to say many of them, they become better at distinguishing similar words, like *bear* and *pear*. Babies at fourteen months will direct their gaze toward an object even when its name is mispronounced, suggesting that their brain does not yet represent the sounds in known words with complete accuracy. Similarly, at this age, brain activity does not distinguish between familiar words and similar-sounding nonsense words. This changes at around twenty months. The relationship between learning words and learning sounds seems to be bidirectional, so that learning sounds makes it easier to learn words, but learning more words also helps babies improve their ability to distinguish sounds.

Sentences add new layers of complexity to language learning. Again, children can comprehend sentences and grammatical connecting words before they're able to use them in speech. To understand a sentence, your child must know not only the meanings of the individual words (called *semantic information*) but also how they relate to each other within the sentence (*syntactic information*). The brain represents these two types of information separately.

For almost everyone (excepting some left-handers), the left hemisphere is dominant for language production. Similar regions in the right hemisphere are responsible for *prosody*, the tone and rhythm of speech that conveys much of its emotional content. (For example, prosody tells you when someone is being sarcastic or making a joke.) Laterality of language representations seems to be part of the basic pattern of brain connections laid down by genes before sensory experience becomes effective (see chapter 2) because it is apparent by two or three months of age and even occurs in deaf infants. If the dominant speech regions are damaged in childhood, though, especially before the age of five, the other side of the brain can take over their function, leaving language skills relatively normal. If the same damage occurs after puberty, it severely impairs communication abilities.

When we hear something that sounds "wrong," event-potentials in our brains reveal whether we're reacting to syntactic or semantic violations. "The boy walked down the flower" is an example of a semantic violation, while "The boy walk

PRACTICAL TIP: TEACH FOREIGN LANGUAGES EARLY IN LIFE

From the perspective of neuroscience, it's absurd to wait until high school to begin studying a foreign language. By adolescence, students must work much harder to learn a new language, and most of them will never master it completely. If you want your child to speak another language fluently, by far the best approach is to start early in life.

In one study, researchers tested the English grammar proficiency of Chinese or Korean immigrants who had arrived in the U.S. at various ages and stayed at least five years. The test required participants to identify whether there were grammatical errors in sentences like "Tom is reading book in the bathtub" or "The man climbed the ladder up carefully." The test was simple enough that native English speakers could ace it by the age of six, but the immigrants who began learning English after age seventeen missed many of these simple questions. Only people who came to the U.S. before age seven performed at the level of native speakers. Everyone in the group who arrived at eight to ten years of age did a bit worse, and those who arrived at eleven to fifteen were still less proficient.

Between ages eight and fifteen, researchers found a strong relationship between age of exposure and performance on the test. But in adulthood, individual variability in performance was not connected to age. No matter whether they'd started learning English at eighteen or forty, few adults learned perfectly. (Some later researchers found that language learning in adulthood also declines with age—that is, young adults learn better than older adults—but everyone agrees that young children learn better than older people.)

The take-home message for parents and schools is clear: take advantage of young children's superior language learning abilities by beginning instruction in elementary school or earlier. When it comes to language, there's no substitute for an early start.

down the road" is syntactic. In small children, these mistake-detection responses develop slowly, starting as children transition from two-word phrases to their first full sentences, around thirty months of age. Brain responses gradually become

faster and more precisely localized through childhood and into the early teens.

There seem to be at least two sensitive periods for language learning. We already discussed the sensitive period for phonemes, in the first year or two of life, when babies' brains become specialized for representing the sounds of their native language(s). There is also a sensitive period for learning about grammar. Children's ability to acquire syntax rules declines gradually after age eight, and adults are worse than children at learning languages (see *Practical tip: Teach foreign languages early in life*).

Some adults manage to learn a second language to a high level of proficiency. Most of us, though, no matter how hard we study in adulthood, will always have a foreign accent and make minor grammatical errors. In contrast, there does not appear to be a sensitive period for semantic learning, as new vocabulary words can be acquired equally well at any age. The event-related potential signal for semantic violations looks the same for both native and second languages, even in people who learned their second language late in life.

Children can learn more than one native language if they are exposed to both languages early enough, but their brains appear to represent the languages at least somewhat separately. Bilingual children reach language milestones at the same age and have the same risk of language impairment as monolingual children, though the details of their language development are somewhat different. So if your household is bilingual, the research indicates that this is not a disadvantage for your child's language learning. (Indeed, it may be an advantage for cognitive development; see *Practical tip: Learning two languages improves cognitive control*, p. 118.) Learning a second language also changes the brain. A region in the left inferior parietal cortex is larger in people who speak more than one language, and it is largest in those who learned the second language when they were young or speak it fluently.

Infants quickly learn to identify different languages by their rhythms, their characteristic phonemes, and other cues. Bilingual children do sometimes mix languages in their speech, but they seem to do so for the same reasons and in the same situations as adult bilinguals, for instance, substituting a word from one language when they don't know the word for that concept in the other one. Though bilingual children have a smaller vocabulary in a particular language than monolingual children of the same age, bilingual children know more words in total if you count both languages.

Children who hear more words while interacting with their parents in the first two years of life learn language faster than children who hear fewer words. These differences in home environments tend to fall along socioeconomic class lines. In one study, the poorest children heard 600 words an hour, working-class children heard 1,200 words, and children of professionals heard 2,100 words. These major differences in children's language environment correlate with their later language development and IQ scores—though the finding that highly verbal parents raise highly verbal children may be partly due to genetic factors or the many other advantages of growing up in a professional household (see chapter 30).

Later research has shown that you can improve your children's language skills by responding rapidly to their vocalizations, mimicking the turn-taking of conversation even before your baby is capable of forming words. Responding with a comment or a touch to your baby's best attempts to communicate seems to encourage continued efforts to improve these skills. So talk to your baby and put up a good show of understanding what she's saying. It's fun for both of you, and it will help her language skills to develop more quickly.