19 First Language Acquisition

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The transition from babbling to the first words marks a major turning point in the life of the infant. With the production of the first words, the child makes a significant step toward integration with human society. The word "infant" derives from the Latin, meaning "without speech." This reflects the fact that, at the time of the first words, the infant ceases being an infant and becomes a child. Some societies believe that, until children begin to speak, they have not yet taken on their full human souls. For this reason, they only give children names after they begin to talk.

Fortunately, the ability to acquire language is present in almost every human child (Lenneberg 1967). Children who are born blind have few problems learning to speak, although they may occasionally be confused about words for colors or spatial locations. Children who are born deaf readily acquire a rich system of signs. If their parents do not know sign language, then they create a set of signs through a process of mutual negotiation with their parents. Even Helen Keller, who had lost both her hearing and sight, was still able to acquire language through symbols expressed in touch and motion. Children with neurological disorders, such as brain lesions or hydrocephalus, often acquire complete control over spoken language, despite a few months of early delay. Given the pervasiveness and inevitability of first language acquisition, we often tend to take the process of language learning for granted. But language is the most complex skill that a human being can master. The fact that nearly all of us succeed in this task indicates how remarkably well the structure of language adapts to our underlying abilities. Language is immensely complex, but its complexity is accessible to all of us.

1 Learning Sounds

1.1 Auditory processing and memory

Language learning begins in the womb. Here, the fetus can pick up the rhythm of the mother's voice and the overall cadence of human language. However, in the womb, the amniotic fluid muffles the sounds available to the fetus. When the baby is born, the auditory and visual world changes suddenly. As the amniotic fluid drains out of the ears and the child opens her eyes, she begins to hear sounds and see sights that were never present before. William James described the world of the newborn as a "booming, buzzing confusion." It is certainly true that the change from the world of the womb to the world outside the womb is radical and severe. But this does not mean that the child is totally unable to structure this new perceptual world.

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Auditory processing relies on extensive pre-processing of signals for pitch and intensity in the cochlea and the auditory nerve. The cochlea is organized much like a xylophone, with hair cells responding to low pitches at the outside and cells responding to high pitches at the other end of the spiral on the inside. This tonotopic organization for pitch and intensity is preserved when the sound reaches the auditory cortex. In order to distinguish between sounds like the /p/ in *pit* and the /b/ in *bit*, the auditory cortex must be able to track things like the onset of resonant sound patterns and the direction of change within specific concentrations of sound pitches called formants. In the 1970s, researchers discovered that human infants were specifically adapted at birth to perceive many of these contrasts. This gave rise to the belief that humans had developed some unique methods for categorically based sound detection. However, subsequent research showed that even chinchillas are capable of making many of these distinctions (Werker 1995). Thus, it appears that much of the basic structure of the auditory world can be attributed to fundamental processes in the mammalian ear.

Beyond this basic level of auditory processing, infants have a remarkable capacity to record and store sequences of auditory events. For example, if the six-month-old hears a sound pattern such as /badigudibagadigudigagidu/ repeated many times, the parts that are repeated will stand out and affect later listening. In this example, the repeated string is /digudi/. If the infant is trained on these strings, she will come to prefer to listen to new sound strings rather than to those that have the old /digudi/ string (Saffran, Aslin, and Newport 1996). This indicates that the infant has come to store the /digudi/ string as a statistically predictable language unit. Researchers believe that this form of statistical learning operates automatically whenever the child is attending to speech. During the first year, the child is exposed to several thousand hours of human language. By continually attending to the auditory patterns of her language, the child can build up a rich repertoire of expectations about the forms of words. However, during this early period, the child still has no idea about the link between sounds and meanings. From the infant's point of view, language is still nothing more than an entertaining, but rather superficial, experience.

In addition to demonstrating early abilities to store sequences of sounds, babies also demonstrate preferences for the language that resembles the speech of their mothers. Thus, a French infant will prefer to listen to French, whereas a Polish infant will prefer to listen to Polish. In addition, babies demonstrate a preference for their own mother's voice, as opposed to that of other women. Together, these abilities and preferences suggest that, during the first eight months, the child is learning a lot about the sounds of language. Although the child is not yet learning words, she is acquiring the basic auditory and intonational patterns of her native language. As she sharpens her ability to hear the contrasts of her native language, she begins to lose the ability to hear contrasts not represented in her native language. If the child is growing up in a bilingual world, full perceptual flexibility is maintained. However, if the child is growing up monolingual, flexibility in processing is gradually traded off for quickness and automaticity.

1.2 Early articulation

Our understanding of infants' auditory processing is based on inferences made from experimental manipulations. In contrast, our understanding of articulatory development is based on a much richer array of directly observable behaviors. During the first three months, a baby's vocalizations can be characterized as various types of cries and vegetative adaptations (burping, sneezing, swallowing, etc.). At around three months, just after the time of the first social smiles, babies begin to make the delightful little sounds that we call "cooing." These sounds have no particular linguistic structure, but their well-integrated intonation makes them sure parent pleasers. The production of these sounds is supported by the infant's increased control of the larynx to produce stable phonations (Oller 2000). By six months, the baby is producing somewhat more structured vocalizations, including a larger diversity of nasals, vowel types, and syllables with the canonical consonant-vowel (CV) structure. The basic framework of early babbling can be

related to patterns of noisy lip-smacking that are present in many primate species (MacNeilage 1998). These vocal gestures include some form of vocal closure followed by a release with vocalic resonance. Essentially, this is the CV syllable in which a consonant is followed by a vowel.

Until the sixth month, deaf infants continue to babble normally. However, by the age of nine months, deaf infants have lost their interest in babbling. This suggests that the babbling present at six months is sustained largely through proprioceptive and somaesthetic feedback, as the baby explores the various ways in which she can play with her mouth. After six months, babbling relies increasingly on auditory feedback. During this period, the infant tries to produce specific sounds to match up with specific auditory impressions. It is at this point that the deaf child no longer finds babbling entertaining, since she cannot obtain auditory feedback. These facts suggest that, from the infant's point of view, babbling is essentially a process of self-entertainment.

Between six and ten months, there is a tight linkage between babbling and general motoric arousal. The child will move her arms, head, and legs while babbling, as if babbling is just another way of getting exercise while aroused. During the last months of the first year, the structure of babbling becomes clearer, more controlled, and more organized. Some children produce repetitive syllable strings, such as /badibadi badibadigu/; others seem to be playing around with intonation and the features of particular articulations.

In the heyday of behaviorism, researchers viewed the development of babbling in terms of reinforcement theory. They thought that the reinforcing qualities of language would lead a Chinese baby to babble the sounds of Chinese, whereas a Quechua baby would babble the sounds of Quechua. This was the theory of "babbling drift." However, closer observation of the babbling of eight-month-olds indicates that virtually no such drift occurs. By 12 months, there is some slight drift in the direction of the native language, as the infant begins to acquire the first words. Proponents of universal phonology have sometimes suggested that all children engage in babbling all the sounds of all the world's language. Here, again, the claim seems to be overstated. Although it is certainly true that some English-learning infants will produce Bantu clicks and Quechua implosives, not all children produce all of these sounds.

2 Learning Words

2.1 The first words

The child's ability to produce the first word is based on three earlier developments. The first is the infant's growing ability to record the sounds of words. The second is the development of an ability to control vocal productions that occurs in the late stages of babbling. The third is the general growth of the symbolic function, as represented in play, imitation, and object manipulation. Piaget characterized the infant's cognitive development in terms of the growth of representation through what he called the "object concept." In the first six months of life, the child is unable to think about objects that are not physically present. However, as the infant learns more about objects, she becomes able to associate their properties with her own actions and other features of the context. In this way, subtle cues can be used to dredge up fuller representations from memory. For example, a child may see a dog's tail sticking out from behind a chair and realize that the rest of the dog is hiding behind the chair. This understanding of how parts relate to wholes supports the child's first major use of the symbolic function. When playing with toys, the 12-month-old will begin to produce sounds such as *vroom* or *bambam* that represent enactive properties of these toys and actions. Often these phonologically consistent forms appear before the first real words. Because they have no clear conventional status, parents may tend to ignore these first symbolic attempts as nothing more than spurious productions or babbling.

If we look at early word learning from the viewpoint of the child, we realize the first steps toward learning words are taken in a fairly passive way. Even before the child has produced her

first conventional word, she has already acquired an ability to comprehend as many as ten conventional forms. She learns these forms through frequent associations between actions, objects, and words. Parents often realize that the prelinguistic infant is beginning to understand what they say. However, they are hard pressed to demonstrate this ability convincingly. Researchers deal with this problem by bringing infants into the laboratory, placing them into comfortable highchairs, and asking them to look at pictures, using the technique of visually reinforced preferential looking (Woodward, Markman, and Fitzsimmons 1994). A name such as "dog" is produced across loudspeakers. Pictures of two objects are then displayed. In this case, a dog may be on the screen to the right of the baby and a car may be on the screen to the left. If the child looks at the picture that matches the word, a toy bunny pops up and does an amusing drum roll. This convinces babies that they have chosen correctly and they then do the best they can to look at the correct picture on each trial. Some children get fussy after only a few trials, but others last for 20 trials or more at one sitting and provide reliable evidence that they have begun to understand a few basic words. Many children show this level of understanding by the tenth month (Oviatt 1980) – often two or three months before the child has produced a recognizable "first word."

This assessment may actually underestimate the time of the first auditory word. Even earlier, there is evidence that the child responds differentially to her own name. If two tapes are played to the right and left side of the six-month-old, the baby will tend to prefer to listen to the tape that includes her own name (Jusczyk 1997). Given the frequency with which the parent uses the child's name and the clarity with which it is typically presented, this is perhaps not too surprising. Although it is unclear whether the child actually realizes what this form means, she is clearly sensitive to its presence and responds when her name is produced.

Given the fact that the ten-month-old is already able to comprehend several words, why is the first recognizable conventional word not produced until several months later? From the viewpoint of the infant, producing the first word is a bit like stepping out on stage without having had sufficient time to rehearse. When she was babbling for her own entertainment, the only constraints the infant faced were ones arising from her own playfulness and interest. Now, when faced with the task of producing word forms, the articulation has to be extremely accurate and within conventional limits. Many of the child's first attempts to produce comprehensible words are so far away from the correct target that even the most supportive parent cannot divine the relation. Eventually, the child produces a clear articulation that makes some sense in context. The parent is amazed and smiles. The child is reinforced and the first word is officially christened.

But all is still not smooth sailing. The child still has no systematic method for going from auditory forms for words she knows to the corresponding articulatory forms. Earlier experience with babbling provides some guide, but now the linkage requires increased precision and control over difficult articulators such as the tongue and the lips. The many simplifications that the one-year-old introduces to adult phonology are well known to students of phonological development (Vihman and Croft 2007). Children tend to drop unstressed syllables, producing *hippopotamus* as *poma*. They repeat consonants, producing *water* as *wawa*. And they simplify and reduce consonant clusters, producing *tree* as *pee*. All of these phonological processes echo similar processes found in the historical development and dialectal variation of adult languages. What is different in child language is the fact that so many simplifications occur at once, making so many words difficult to recognize.

2.2 *Early semantics*

The salience of early articulatory limitations tends to mask other, more subtle, challenges facing the toddler. With only a few words to her name, there is no great danger that one word will be confused with another. However, as the toddler's inventory of words grows, the challenge of keeping these words apart also grows. The toddler is torn between two opposing strategies. On

the one hand, children often try to be conservative in their first uses of words. For example, a child may use the word *dog* to refer only to the family dog and not to any other dog. Or a child may use the word *car* to refer only to cars parked in the driveway and not cars in any other context. This tendency toward undergeneralization can only be detected if one takes careful note of the contexts in which a child avoids using a word. The flipside of this coin is the strategy of overgeneralization. It is extremely easy to detect overgeneralizations. If the child calls a tiger a *kitty*, this is clear evidence for overgeneralization. Of course, it is always possible that the children really meant to say something like, *that animal over there reminds me a lot of my kitty*. However, if the child intended this, they would be relying on nonstandard ideas about how words are used.

At first, both undergeneralization and overgeneralization are applied in a relatively uncontrolled fashion. The child's first applications of undergeneralization are unreasonably rigid and she soon learns that most words apply to a wide range of possible referents. At the same time, the child's first attempts at generalization are also often wildly overproductive. For example, a child may use the word *duck* first to refer to the duck, then to the picture of an eagle on the back of a coin, then to a lake where she once saw ducks, and finally to other bodies of water. These pleonastic extensions of forms across situations are fairly rare, but they provide interesting commentary regarding the thinking of the toddler when they do occur.

It would be fair to say that all children engage in both undergeneralization and overgeneralization of word meanings (Dromi 1987). At the same time, it is remarkable how accurate children are in their early guesses at the correct meanings of words. They quickly come to realize that words can be used across a variety of situations in addition to the original context in which they were used. This is fortunate, since reality never repeats itself. If a child thought that a word was limited to use in the original context, there would seldom be an opportunity to reuse a word. Instead, the child has to take each context and decide which aspects are likely to be generalizable for repeated uses of the word. But figuring out how to reuse words is not a trivial problem. In fact, scholars from Plato to Quine have considered the task of figuring out word meaning to be a major intellectual challenge. Quine (1960) illustrated the problem by imagining a scenario in which a hunter is out on safari with a native guide. Suddenly, the guide shouts *Gavagai*! The hunter, who does not know the native language, has to quickly infer the meaning of the word. Does it mean *shoot now*! or *there's a rhino* or perhaps even *it got away*? Without some additional cues regarding the likely meaning of the word, how can the hunter figure this out?

The problem facing the toddler is similar to that facing the hunter. Fortunately, the toddler has some good cues to rely on. Foremost among these cues is the parent's use of joint attention and shared eye gaze to establish common reference for objects and actions. If the father says *hippo* while holding a hippopotamus in his hand, the child can use the manual, visual, verbal, and proxemic cues to infer that the word *hippo* refers to the hippopotamus. A similar strategy works for the learning of the names of easily produced actions such as falling, running, or eating. It also works for social activities such as *bath* or *bye-bye*. The normal child probably understands the role of shared eye gaze even before learning the first words. At three months, children maintain constant shared eye gaze with their parents. In normal children, this contact maintains and deepens over time. For autistic children, contact is less stable and automatic. As a result, autistic children may be delayed in word learning and the general growth of communication.

The importance of shared reference is obvious to most parents. In fact, in the fanciful recollections in his *Confessions* (405 CE), St. Augustine outlined an analysis not very different from the one presented here:

> This I remember; and have since observed how I learned to speak. It was not that my elders taught me words (as, soon after, other learning) in any set method; but I, longing by cries and broken accents and various motions of my limbs to express my thoughts, that so I might have my will, and yet unable to express all I willed or to whom I willed, did myself, by the understanding which Thou, my God, gavest me, practice the sounds in my memory. When they named anything, and as they spoke turned

> towards it, I saw and remembered that they called what they would point out by the name they uttered. And that they meant this thing, and no other, was plain from the motion of their body, the natural language, as it were, of all nations, expressed by the countenance, glances of the eye, gestures of the limbs, and tones of the voice, indicating the affections of the mind as it pursues, possesses, rejects, or shuns. And thus by constantly hearing words, as they occurred in various sentences, I collected gradually for what they stood; and, having broken in my mouth to these signs, I thereby gave utterance to my will. Thus I exchanged with those about me these current signs of our wills, and so launched deeper into the stormy intercourse of human life, yet depending on parental authority and the beck of elders.

Shared reference is not the only cue the toddler uses to pick out the reference of words. She also uses the form of utterances to derive the meanings of new words. For example, if the toddler hears *here is a zav*, she knows that *zav* is a common noun. However, if she hears *here is Zav*, then she knows that *Zav* is either a proper noun or perhaps the name of a quantity (Katz, Baker, and Macnamara 1974). If she hears *I want some zav*, she knows that *zav* is a quantity and not a proper or common noun. Cues of this type can give a child a rough idea of the meaning of a new word. Other sentential frames can give an even more precise meaning. If the child hears *this is not green, it is chartreuse*, then it is clear that *chartreuse* is a color. If the child hears, *please don't cover it, just sprinkle it lightly*, then the child knows that *sprinkle* is a verb of the same general class as *cover*. The use of cues of this type leads to a fast, but shallow, mapping of new words to new meanings.

2.3 *Mutual exclusivity and competition*

Even the fullest set of syntactic cues and the clearest shared attention cannot prevent occasional confusion regarding word meanings. Some of the most difficult conflicts between words involve the use of multiple words for the same object. For example, a child may know the word *hippo* and hear her toy hippo referred to as a *toy*. Does this lead her to stop calling the toy a *hippo* and start calling it a *toy*? Probably it does not, although it may lead her to pay increased attention to the word *toy*. Some have suggested that children are prevented from making this type of error by the presence of a universal constraint called "mutual exclusivity." This constraint holds that each object can only have one name. If a child hears a second name for the old object, she can either reject the new name as wrong, or else find some distinction that disambiguates the new name from the old. If mutual exclusivity constrains word meaning, we would expect children to show a strong tendency toward the first solution – rejection. However, few children illustrate such a preference (Merriman and Bowman 1989). The problem with the rejection solution is that objects almost always have more than one name. For example, a *fork* is also *silverware* and a *dog* is also an *animal*. Linguistic structures expressing a wide variety of taxonomic and metonymic relations represent a fundamental and principled violation of the proposed mutual exclusivity constraint. The most consistent violations occur for bilingual children who learn that everything in their world must, by necessity, have at least two names. Mutual exclusivity is clearly not a basic property of natural language.

One reason why researchers have tended to devote so much attention to mutual exclusivity stems from the shape of the laboratory situation in which word learning is studied. The child is presented with a series of objects, some old and some new, given a word that is either old or new, and then asked to match up the word with an object. For example, the child may be given a teacup, a glass, and a demitasse. She already knows the words *cup* and *glass*. The experimenter asks her to *give me the demitasse*. She will then correctly infer that *demitasse* refers to the object for which she does not have a well-established name (Golinkoff et al. 1992). In this context, it makes sense to use the new name as the label for some new object.

Instead of thinking in terms of mutual exclusivity, the child appears to be thinking in terms of competition between words, with each word vying for a particular semantic niche (Merriman

1999). The child also thinks in terms of the pragmatics of mutual cooperation. When two words are in head-on conflict and no additional disambiguating cues are provided, it makes sense for the child to assume that the adult is being reasonable and using the new name for the new object. The child assumes that, like a cooperative parent, the experimenter knows that the child has words for cups and glasses, so it only makes sense that the new word is for the new object.

In the real world, competition forces the child to move meanings around so that they occupy the correct semantic niche. When the parent calls the toy hippo a *toy*, the child searches for something to disambiguate the two words. For example, the parent may say *can you give me another toy*? or *please clean up your toys*. In each case, *toy* refers not just to the hippo, but also potentially to many other toys. This allows the child to shift perspective and to understand the word toy in the framework of the shifted perspective. Consider the case of a rocking horse. This object may be called *toy*, *horsie*, or even *chair* depending on how it is being used at the moment. This flexible use of labeling is an important ingredient in language learning. By learning how to shift perspectives, children develop powerful tools for dealing with the competitions between words. In this way conflicts between meanings give rise to complex structures and cognitive flexibility.

2.4 Humpty-Dumpty and Whorf

In Lewis Carroll's *Through the Looking Glass*, Humpty-Dumpty chastises Alice for failing to take charge over the meanings of words. As he puts it, "When I use a word, it means just what I choose it to mean – neither more nor less." Undoubtedly, many children attempt to adopt this take-charge attitude toward language learning. The problem is that, without understanding conventional meanings, both children and Humpty-Dumpty could find themselves using words in ways that no one else would understand.

Children often have a rather fixed agenda of items to be expressed and would love to find simple ways of expressing each of those items. For example, many children want to learn words for finger, hand, ball, dog, bottle, Mommy, Daddy, and food. Most languages will oblige the child by providing words for these very basic concepts. However, once we leave the level of the first 20 words, all bets are off. Languages like Korean or Navajo require the child to learn verbs instead of nouns. Moreover, the verbs they learn focus more on position, shape, and containment than do verbs in English. For example, the verb *'ahééníshtiih* in Navajo refers to *carrying around in a circle any long straight object such as a gun*. As learning progresses, the child's agenda becomes less important than the shape of the resources provided by the language. This is not to say that languages end up shaping core features of children's cognitions. However, the presence of obligatory grammatical markings in languages for concepts such as tense, aspect, number, gender, and definiteness can orient the child's thinking in certain paths at the expense of others. Benjamin Whorf suggested many years ago that the forms of language shape the structure of thought. Such effects are directly opposed to the Humpty-Dumpty agenda-based approach to language. Probably the truth lies somewhere between Whorf and Humpty-Dumpty. Important though language-specific effects may be, all children end up being able to express basic ideas equally well, no matter what language they learn.

3 Learning Grammar

3.1 The first word combinations

Throughout the second year, the child struggles with perfecting the sounds and meanings of the first words. For several months, the child produces isolated single words. With a cooperative parent, a child can go a long way with this level of language. For example, if a child is hungry, it is enough to simply say *cookie*. There is no reason to say, *would you please open the cupboard door and*

bring me down a cookie. In fact, most of the child's basic needs are met even without the intervention of language. Sometimes a child may be frustrated by the parent's failure to understand her intentions. This frustration can be a strong motivator toward acquiring fuller communication. However, it is unlikely that needs and frustrations are the roots of linguistic development. Nor is language learned simply for the sake of imitating adults. Instead, it seems that children learn to speak so that they can articulate a fuller shared view of the world.

Single words are not enough to articulate this fuller view. Instead, children need to be able to associate verbs or "predicates" such as *want* or *go* with nouns or "arguments" such as *cookie* or *Mommy*. In addition to verbs, predicates can include other words that modify nouns such as adjectives, determiners and prepositions. In general, predicates are words that "say something" or "make a predication" about the nouns to which they are attached. This linkage of predicates to arguments is the first step in syntactic development (MacWhinney 2014). As in the other areas of language development, these first steps are taken in a very gradual fashion. Before producing a smooth combination of two words such as *my horsie*, children will often string together a series of single word utterances that appear to be searching out some syntactic form. For example, a child might say *my, that, that, horsie* with pauses between each word. Later, the pauses will be gone and the child will say *that horsie, my horsie*. This tentative combination of words involves groping on both intonational and semantic levels. On the one hand, the child has to figure out how to join words together smoothly in production. On the other hand, the child also has to figure out which words can meaningfully be combined with which others.

As was the case in the learning of single words, this learning is guided by earlier developments in comprehension. As in the case of studies of early word comprehension, we have to assess children's early syntactic comprehension by controlled experiments in the laboratory. Here, again, researchers have used the preferential looking paradigm. To the right of the child, there is a TV monitor with a movie of Big Bird tickling Cookie Monster. To the child's left, there is a TV monitor with a movie of Cookie Monster tickling Big Bird. The loudspeaker produces the sentence *Big Bird is tickling Cookie Monster*. If the child looks at the matching TV monitor, she is reinforced and a correct look is scored. Using this technique, researchers have found that 17-month-olds already have a good idea about the correct word order for English sentences. This is about five or six months before they begin to use word order systematically in production.

The level of successive single word utterances is one that chimpanzees also reach when they learn signed language. Domesticated chimps like Sarah, Washoe, or Kanzi have succeeded in learning over a hundred conventional signs or tokens. They can then combine these words to produce meaningful communication. However, the combinations that chimpanzees produce never really get beyond the stage of successive single word utterances. Thus, it appears that children rely on some uniquely human ability for structuring combinations of predicates and arguments into tighter syntactic combinations. The exact neurophysiological basis of this ability is still unknown, although many researchers suspect that the growth of inferior frontal areas for motor control supports the ability to combine words into simple combinations.

The grammar of the child's first combinations is extremely basic. The child learns that each predicate should appear in a constant position vis-à-vis the arguments it requires. For example, in English, the word *more* appears before the noun it modifies. We can describe this relation as an item-based pattern in which the word *more* serves as the head item that opens up a slot that is filled by a following noun. In this case, *more* opens up a slot for a following noun. When a noun, such as *milk*, is selected to appear with *more*, that noun fills the slot opened up by the word *more*. The result is the combination *more milk*. Later, the child can treat this whole unit as an argument that drops into the direct object slot opened up by the verb *want* and the result is *want more milk*. Finally, the child can express the second argument of the verb *want* and the result is *I want more milk*. Thus, the child builds up longer and longer sentences and a more complex grammar. This level of simple combinatorial grammar is based on individual words as the controlling structures. This type of word-based learning is present even in adults. In languages with strong

morphological marking systems, word-based patterns specify the attachment of affixes, rather than just the linear position of words. In fact, most languages of the world make far more use of morphological marking than does English. In this regard, English is a rather exotic language.

3.2 *Missing glue*

The child's first sentences are almost all incomplete and ungrammatical. Instead of saying *this is Mommy's chair*, the child produces only *Mommy chair* with the possessive suffix, the demonstrative, and the copula verb all deleted. Just as the first words are full of phonological deletions and simplifications, the first sentences include only the most important words, without any of the glue. In some cases, children simply have not yet learned the missing words and devices. In other cases, they may know the "glue words" but find it difficult to coordinate the production of so many words in the correct order.

These early omissions provide evidence for two major processes in language development. First, the child makes sure that the most important and substantive parts of the communication are not omitted. Unfortunately, the child makes this evaluation from her own, egocentric, perspective. In an utterance like *Mommy chair* it is not clear whether the child means *this is Mommy's chair* or *Mommy is sitting in the chair*, although the choice between these interpretations may be clear in context. The second factor that shapes early omissions is phrasal frequency. Children tend to preserve frequent word combinations, such as *like it* or *want some*. These combinations are often treated as units, producing errors such as *I like it the ball* or *I want some a banana*.

In English, omissions of auxiliaries are extremely common. For many months, children will produce questions without auxiliaries, as in *why he go to the store*? for *why does he go to the store*? or *why not she come*? for *why won't she come*?" In languages with richer systems of morphological marking, the most common errors involve the use of the most frequent form of a noun or verb, even when some marked form is required. For example, in German child language, the infinitive is often used when a finite verb is required. These various errors can be traced to the fact that the child has limited resources to produce complex sentences and tends to settle for well-known forms in simple combinations.

3.3 *Productivity*

Productivity can be demonstrated in the laboratory by teaching children names for new objects. For example, we can show a child a picture of a funny looking creature and call it a *wug*. As we noted before, the positioning of the word *wug* after the article *a* induces the child to treat the word as a common noun. The child can then move from this fact to infer that the noun *wug* can pluralize as *wugs*, even if she has never heard the word *wugs* (Berko 1958). This type of productive generalization of linguistic patterns occurs from the earliest stages of language acquisition. For example, a German-speaking child can be taught the nonce name *der Gann* (nominative, masculine, singular) for a toy. The experiment can then pick up the toy and ask the child what he is holding. Even three-year-olds understand that *Gann* should be accusative. So, they correctly produce the form *den Gann*.

Three-year-olds also demonstrate some limited productive use of syntactic patterns for new verbs. However, children tend to be conservative and unsure about how to use verbs productively until about age five. After all, from the child's perspective these laboratory experiments with strange new toys and new words may tend to encourage a conservative approach. As they get older and braver, children start to show productive use of constructions such as the double object, the passive, or the causative. For example, an experimenter can introduce a new verb like *griff* in the frame *Tim griffed the ball to Frank* and the child will productively generalize to *Tim griffed Frank the ball.*

The control of productivity is based on two complementary sets of cues: semantics and co-occurrence. When the child hears *a wug*, she correctly infers that *wug* is a count noun. In fact, because she also sees a picture of a cute little animal, she infers that *wug* is a common, count, name for an animate creature. These semantic features allow her to generalize her knowledge by producing the form *wugs*. However, we could also view this extension as based on co-occurrence learning. The child learns that words that take the indefinite article also form plurals. On the other hand, words that take the quantifier *some* do not form plurals. In this way, the child can use both semantics and co-occurrence information to build up knowledge about the parts of speech. This knowledge about parts of speech can then be fed into existing syntactic generalizations to control the production of new combinations (Li, Zhao, and MacWhinney 2007).

3.4 The logical problem of language acquisition

The problem with productivity is that it produces overgeneralization. For example, an English-speaking child will soon learn to form the past tense of a new verb by adding one of the variant forms of *–ed*. This knowledge helps the child produce forms such as *jumped* or *wanted*. Unfortunately, it may also lead the child to produce an error such as **goed*. When this occurs, we can say that the child has formulated an overly general grammar. One way of convincing the child to reject the overly general grammar in which *goed* occurs is to provide the child with negative feedback. This requires the parent to tell the child, *no, you can't say "goed."* The problem here is that children may often ignore parental feedback regarding the form of language. If the child calls a hamburger a *hot dog*, the parent can tell her *no, it is a hamburger*. The child will accept this type of semantic correction. But children are notoriously resistant to being corrected for formal grammatical features.

The fact that children tend to ignore formal correction has important consequences for language acquisition theory. In the 1970s, work in formal analysis convinced some linguists that the task of learning the grammar of a language was impossible, unless negative feedback was provided. Since negative feedback appeared to be unavailable or unused, this meant that language could not be learned without some additional innate constraints. This argument has led to many hundreds of research articles exploring the ways in which children's learning places constraints on the form of grammar. Referring back to Plato's ideas about the difficulty of perceiving true forms, researchers have characterized the task of language learning as a logical problem. At its core, most of the search for innate constraints on language learning is grounded on the supposed impossibility of recovery from overgeneralization. To illustrate the ongoing importance of these issues for linguistic theory and language acquisition, consider this passage from Chomsky (1965: 58):

> It is for the present, impossible to formulate an assumption about initial, innate structure rich enough to account for the fact that grammatical knowledge is attained on the basis of the evidence available to the learner. Consequently, the empiricist effort to show how the assumptions about a language acquisition device can be reduced to a conceptual minimum is quite misplaced. The real problem is that of developing a hypothesis about initial structure that is sufficiently rich to account for acquisition of language, yet not so rich as to be inconsistent with the known diversity of language.

In fact, the child has more resources available to her than Chomsky seems to suggest. Using these resources, the child can recover from overgeneralization without negative feedback. In the case of *goed*, everyone agrees that recovery is easy. All the child has to do is to realize that there is only one way of producing the past tense of *go* and that is *went*. In other words, the irregular form *went* comes to block production of the over-regularized form *goed*. Here, recovery from overgeneralization is based on the competition between the regular pattern and the irregular form. In such competitions, the irregular form must always win.

However, not all recovery from overgeneralization is so simple. Suppose that a child decides to base the syntax of the verb *recommend* on that of the verb *give*. After all, both verbs involve a beneficiary and an object being transferred. However, only *give* allows a double object construction, as in *John gave the library the book*. Most people find *John recommended the library the book* ungrammatical. If the child makes this error, how does she recover? One solution to this error is to avoid making the error in the first place. If the child proceeds cautiously, learning each construction verb by verb, she will never attempt to use the verb *recommend* with the double object construction. Most children follow this course and never make the error. However, other children are less cautious. Do we want to assume that the cautious children have no need for innate constraints and that the less cautious children do? Fortunately there is a better way for even the incautious children to solve this "logical" problem.

The solution here is to record the strength of competing syntactic patterns. The correct way of saying *John recommended the library the book* is to say *John recommended the book to the library*. This correct formulation should be strengthened whenever it is heard. As the strength of the frame for the verb *recommend* grows in comparison to the ungrammatical frame, the use of the competing frame is blocked. This solution assumes that the child realizes that the two frames are in competition. It may be that reaching this realization requires some attention to syntactic form. However, this solution does not require the child to pay attention to corrective feedback. Instead, she only needs to attend to correct sentences and to make sure that she understands that these are competing ways of saying roughly the same thing.

3.5 Lexical groups

Most overgeneralizations can be controlled in a rote fashion. This involves strengthening single constructions for single verbs. However, there are some cases where stronger medicine may be necessary. Consider errors such as **I poured the tub with water* or **I filled water into the tub*. The use of a goal construction versus a direct object to express the entity being filled depends very much on the semantics of the verb. In effect, the child has to learn to break up the general class of pouring verbs into two subclasses, based on evidence from semantics and co-occurrence. Earlier, we discussed the role of lexical groups in supporting productivity. The problem here is the same one. However, the distinction is rather subtle, both semantically and syntactically. Verbs like *pour* do not emphasize the completion of the activity, but rather the ongoing process of transfer. These verbs use a goal construction. Verbs like *fill* tend to emphasize the completion of the activity and the change in state of the affected object. Most children learn to use these verbs conservatively and never produce these errors. However, once they are produced, the easiest way to correct them is to solidify the distinction between the two classes. Researchers (Li, Zhao, and MacWhinney 2007) have shown how the details of this learning process can be modeled formally using neural network models. Distinctions as subtle as this may not be acquired until the child produces some errors. Since errors of this type may not arise until about age six or later, the formation of lexical subclasses of this type is a rather late development.

Consider another example of how lexical classes help the child recover from overgeneralization. For example, a child might notice that both *cow* and *red* pattern together in forms such as *cow barn* and *red barn*. This might induce the child to produce forms such as *I painted the barn cow* on analogy with *I painted the barn red*. A conservative learner would stick close to facts about the verb *paint* and the arguments that it permits. If the child has heard a form like *I painted the barn white*, it would make sense to extend this frame slightly to include the resultative predicate *red*. However, an extension past the realm of colors and patterns would violate the basic principles of conservative learning. As a result, this type of category-leaping overgeneralization is extremely infrequent.

3.6 Errors that never occur

We have seen how children can recover from overgeneralization without relying on innate constraints. However, there is another approach to language development that provides more convincing evidence for innate constraints. This approach focuses on errors that "never" occur. Consider this example:

(1) a. The boy who is first in line will get the prize.
b. Will the boy who is first in line get the prize?
c. *Is the boy first in line will get the prize?

The claim here is that a simple surface analysis of the grammar would have led the child to produce (1c) instead of (1b). However, only (1b) is consistent with universal grammar, since auxiliaries are always derived from the main clause and not from some subordinate clause. Chomsky and others have claimed that children never hear sentences like (1b). It is certainly true that such sentences are not common, but it is not true that they never occur. Although the argument fails to go through in this case, the basic observation seems solid. Would a child even dream of producing something like (1b)? It seems unlikely. Moreover, it seems likely that, when the child learns to produce auxiliaries in questions, this learning is based not on surface word order, but on the underlying conceptual relations between words. It remains to be seen whether this learning amounts to evidence for innate constraints on grammar.

Similar analyses have been developed for a variety of other constructions. Examples (2) through (5) illustrate four additional patterns.

(2) a. You put it on a hot plate.
b. You put it on a hot what?
c. *What did you put it on a hot?

(3) a. Do you think a picture of Luke Skywalker should be on my cake?
b. Do you think a picture of who should be on my cake?
c. *What do you think a picture of should be on my cake?

(4) a. She chased the boy who stole her sandwich.
b. She chased the boy who stole her what?
c. *What did she chase the boy who stole?

(5) a. Luisa stood between the bookshelf and the fireplace.
b. Luisa stood between the bookshelf and what?
c. *What did Luisa stand between the bookshelf and?

In the case of (2c) and (3c), there is evidence that children actually produce the "nonoccurring" error. In fact, Bob Wilson's son Seth produced (2c) and my son Mark produced (3c). The corpora of child language data from which these examples were taken can be found in the CHILDES corpus on the web at http://childes.psy.cmu.edu.

Errors such as (4c) and (5c) have never been reported. Indeed, the constraints that block (4c) and (5c) are some of the most powerful constraints that have been identified in the linguistic literature. Both (4b) and (4c) seem to be possible ways of expressing these questions. However, they only make sense if we imagine conditions of noise that blocked out a single word. Not hearing well, we then echoed the sentence to try to recover the missing word. This suggests that neither (4c) nor (5c) is really well formed on semantic grounds.

3.7 Emergentist accounts

Our overview of language learning has focused on the challenges facing the child. We have also looked at language development from the viewpoint of Universal Grammar. Now we turn our attention to psychological views on language learning. Typically, psychologists see linguistic knowledge as emerging from regularities in the language heard by the child. To model the processes and mechanisms involved in this learning, many psychologists rely on the formalisms of neural network theory, which is also known as connectionism. This framework uses large numbers of units and the connections between these units to capture the patterns of language. This weblike architecture of nodes and connections is intended explicitly to resemble the structure of the human brain with neurons, synapses, and weights on synaptic connections.

Without burdening the reader with all the technical paraphernalia of neural network theory, let us take a brief look at how this type of analysis can be applied to a concrete problem in language acquisition. Let us take as an example the learning of German gender, as marked by the definite article (the word *the* in English). The task facing the German child is to combine each noun with one of the six different forms of the definite article. The article can take the form *der*, *die*, *das*, *des*, *dem*, or *den*. The choice of one of these six forms depends on three features of the noun: its gender (masculine, feminine, or neuter); its number (singular or plural); and its role within the sentence (subject, possessor, direct object, prepositional object, or indirect object). To make matters worse, assignment of nouns to gender categories is often quite nonintuitive. For example, the word for *fork* is feminine, the word for *spoon* is masculine, and the word for *knife* is neuter. Acquiring this system of arbitrary gender assignments is particularly difficult for adult second language learners. In his treatise on the "Aweful German Language," Mark Twain complained that German treats pretty young girls as neuter, the sun as feminine, and the moon as masculine. Twain was convinced that the choice of gender in German made no sense at all.

Although the cues governing German gender are complex, it is possible to construct a connectionist network that learns the German system from the available cues (MacWhinney et al. 1989). To do this, the network is presented with a series of patterns across the "input units." Each pattern represents the phonological form of a given German noun. For example, a particular node may be used to code the fact that the first consonant in the third syllable is a voiceless consonant like /p/ or /t/. Using 168 of these feature units, it is possible to given a different input pattern for each of the 102 nouns that were used to train the network. For each noun, the input also includes features that determine the noun's case and number.

Processing begins when the input layer is given a particular German noun. For example, the input could be the phonological form of the masculine noun *Tisch* (table), along with information that the noun is in the accusative and is singular. These active input units then spread activation to the other units in the system and eventually the activation reaches the six possible output units – one for each of the six forms of the definite article. The output unit that receives the most activation is the one that is chosen for the noun on this trial. On the first pass through, the network will probably choose the wrong output. In this case, the output might be the article *die*. This is wrong, since it treats the masculine noun *Tisch* as if it were feminine. When this occurs, the learning algorithm goes through all the connections in the network and adjusts them so that they are a bit closer to what would have been needed to activate the correct output item. This training continues for 50 cycles that repeat each of the nouns in the input corpus. At the end of this training period, the network is able to choose the correct article for 98 percent of the nouns in the original set.

To test its generalization abilities, we next present the network with old nouns in new case roles. If the network learned *Tisch* in the accusative, we now give it *Tisch* in the genitive and it should select the article *des*. In these tests, the network chooses the correct article on 92 percent of trials. This type of cross-paradigm generalization provides evidence that the network went beyond rote memorization during the training phase. In fact, the network quickly succeeds in

learning the whole of the basic formal paradigm for the marking of German case, number, and gender on the noun.

In addition, the network is able to generalize its internalized knowledge to solve the problem that had so perplexed Mark Twain – guessing at the gender of entirely novel nouns. The 48 most frequent nouns in German that had not been included in the original input set are then presented in a variety of sentence contexts. On this completely novel set, the network chooses the correct article from the six possibilities on 61 percent of trials, versus 17 percent expected by chance. Thus, the system's learning mechanism, together with its representation of the noun's phonological and semantic properties and the context, produced a good guess about what article would accompany a given noun, even when the noun was entirely unfamiliar.

The network's learning parallels children's learning in a number of ways. Like real German-speaking children, the network tends to overuse the articles that accompany feminine nouns. The reason for this is that the feminine forms of the article have a high frequency, because they are used both for feminines and for plurals of all genders. The simulation also showed the same type of overgeneralization patterns that are often interpreted as reflecting rule use when they occur in children's language. For example, although the noun *Kleid* (which means clothing) is neuter, the simulation used the initial "kl" sound of the noun to conclude that it is masculine. Because of this, it chooses the form of the definite article that would accompany the noun if it were masculine. Interestingly, the same article–noun combinations that are the most difficult for children are also the most difficult for the network.

How is the network able to produce such a high level of generalization and such rule-like behavior without any specific rules? The basic learning mechanism involves adjusting connection strengths between input, hidden, and output units to reflect the frequency with which combinations of features of nouns were associated with each article. Although no single feature can predict which article would be used, various complex combinations of phonological, semantic, and contextual cues allow accurate prediction of which articles should be chosen. This is the sense in which language learning often seems to be based on the acquisition of cues, rather than rules.

4 A Fourth Perspective

Alongside the perspective of the linguist, the psychologist, and the child, we can also look at language learning from the viewpoint of the parent and the educator. Parents often worry about the fact that their child may be slow at learning to talk. When a child falls behind, the parent and the educator want to know how to help the child catch up. However, experience shows us that the overwhelming majority of late talkers end up with full control over language. Often children are simply insufficiently motivated to talk. A prime example of this type is Albert Einstein, who did not begin talking until age five. His case is a bit extreme, but certainly not unique. Even children who have lost portions of their cerebral cortex as a result of early brain injuries end up acquiring full control over language use, as long as they are raised in a normal, supportive family.

Nearly 1 out of 20 children suffers from some form of language impairment. In many cases, language impairment is an accompaniment to some other obvious cognitive or emotional impairment, such as Down syndrome, Williams syndrome, Fragile-X syndrome, or autism. Each of these genetically based syndromes has a wide variance of expression, with some children achieving normal control of language and others less adequate language. Another, much larger, group of children evidences some level of language impairment without any obvious genetic abnormality. These children can be further divided into about four major groups. In the first group, only the expressive use of language is impaired. Children with expressive impairments may find it difficult to articulate certain sounds or may stutter. These children typically have

little impairment in language comprehension and no cognitive deficit. This deficit can be treated by articulatory speech therapy. A second group of children has deficits in low-level speech perception for sounds like /s/ and /f/. Careful training in the detection of auditory contrasts can help remediate this impairment. A third group of children shows some form of pragmatic impairment. These children have problems forming coherent discourse and connected narration. In some cases, this "deficit" may reflect stylistic effects related to dialect and social class. In other cases, it may reflect innate tendencies such as autism or difficulties with social perspective taking. Finally, there is a fourth group of children that have slight cognitive deficits that may be related to language impairments.

We are now just beginning to understand the neurological and genetic bases of these various impairments. Studies of familial genetic profiles have given us some clues regarding ways in which biology may determine language impairment. Recent advances in brain imaging methodology are now opening up the possibility of observing the actual neurophysiological bases of language processing as it occurs. Application of these new methods to the study of language impairments will help us better understand both normal and abnormal language development.

Not all parental concerns focus on language delay. Parents are also deeply interested in furthering normal progress and promoting genius. In some cases, the parent may find that the child has unusual interests in language and wants to help the child to develop these interests, whether they involve learning additional languages, growing up bilingual, or merely being introduced at an early age to great literature. Research on the roots of literacy has indicated the continuity between early literary practices such as reading books with children, reciting rhymes, or fantasy role-play and later success in reading and literacy (Snow 1999).

5 Conclusion

Language is a unique marker of humanity. It distinguishes the human species from the rest of the creation, and it allows us to share our thoughts and feelings. Language is the most complex skill that any of us will ever master. Despite this complexity, nearly every human child succeeds in learning language. This suggests that language is optimally shaped to mesh with the abilities of the human mind and body. On the one hand, the universals of human language match up with our neurological, cognitive, and physical abilities. At the same time, parents provide rich contextual and emotional support to guide children through the process of language discovery. By studying language learning, we learn more about universals of human language, the shape of social interaction, and the structure of the human mind.

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RELEVANT JOURNALS AND SOCIETIES

Journals
Journal of Child Language
First Language
Language Learning and Development
Language Acquisition

Societies
Boston University Conference of Language Development
Child Language Seminar
International Association for the Study of Child Language
Stanford Child Language Research Forum

EMERGING TRENDS AND RESEARCH QUESTIONS

1. Is there any fundamental difference between first and second language acquisition, or are the differences a result of the fact that adults already have a language in place?
2. At age seven, many children are still disfluent, but over 80 percent of these children do not end up stuttering. Does this indicate that early intervention could help the other 20 percent?
3. To what degree can we attribute different patterns of academic success to early patterns of language usage and shared social routines? Which patterns lead to the best academic outcomes and how can they be encouraged in families and in the schools?
4. How can advances in the study of human and primate genetics help us understand the biological bases for the evolution of human language?

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