Everybody's Talkin'

Language's great innate debate continues to make noise

By BRUCE BOWER

The chorus of a popular song from nearly 30 years ago proclaims "Everybody's talkin' at me, I can't hear a word they're sayin', only the echoes of my mind."

A vocally precocious but otherwise typical baby might paraphrase those sentiments as follows: "Everybody's talkin' at me, I hear every word they're sayin', it's all echoing through my mind. And if someone doesn't take care of this diaper and give me some milk, I'll scream!"

Okay, babies don't talk, and their song lyrics consist of incessant babbling. Nonetheless, young children move from a conversational crawl to linguistic leaps in a matter of months, typically beginning sometime between their first and second birthdays. A burgeoning number of studies indicates that language learning begins long before infants utter their first words, probably within the womb upon hearing their mother's voice.

Several factors have rekindled the debate over how people learn to talk. Researchers have increasing respect for infants' talent for soaking up language, and there is growing evidence of the brain's facility for reorganizing itself in light of new experiences. Moreover, computer systems that squeeze knowledge out of simple arrays of processing units are being developed as models of how learning occurs in the brain.

"There's a war going on between competing views of the nature of language," says psychologist Mark S. Seidenberg of the University of Southern California in Los Angeles. "On a deeper level, it's an argument about what innateness means and where knowledge comes from."

Philosophers have quarreled over these issues for centuries. Current scientific turmoil focuses on the influential theory launched more than 30 years ago by Massachusetts Institute of Technology linguist Noam Chomsky. From an imposing thicket of jargon cloaking technical analyses of spoken sentences, Chomsky attacked the assumption that children learn to talk thanks solely to the guidance of their parents and the wider culture.

Kids wield innate knowledge about rules for constructing sentences in any language, Chomsky argued. Armed with a facility for universal grammar, as he dubbed it, the average toddler formulates a plan for speaking a native tongue based on the overheard conversations of a limited circle of adults. The youngster then creates all sorts of novel, meaningful expressions, as well as predictable kinds of errors.

Inspired by evolutionary theory, some scientists have elaborated on Chomsky's proposal. In their view, humanity's gift of gab derives from genetically sculpted brain circuits devoted to basic grammar and word skills. Through their contributions to our ancestors' survival, such prewired mechanisms assumed neural prominence over thousands of generations, according to these researchers.

"Language is a distinct piece of the biological makeup of our brains," wrote MIT psychologist Steven Pinker in his 1994 book *The Language Instinct* (New York: W. Morrow). "People know how to talk in more or less the sense that spiders know how to spin webs."

Two related realms of investigation now challenge Pinker's view, Seidenberg asserts in the March 14 SCIENCE. The first has more to do with nets than with webs. Connectionist, or neural network, theories try to explain various behaviors or mental feats by drawing analogies with the learning exhibited by interconnected processing units in a computer system. The mathematical strength of connections among these units gradually changes as the system learns to solve a particular problem. The computer network eventually assumes a stable pattern of activity that successfully tackles both the familiar problem and related new challenges.

For instance, some connectionist researchers interested in language have devised computer networks that learn to predict which words will appear next in incomplete sentences. In much the same way, a child's early grammatical insights may depend on establishing criteria for what makes utterances well formed versus awkward or confusing, these scientists propose. Thus, grammatical skills may accumulate through experience without the rigid guidance of innate language centers in the brain.

A second body of data indicates that speech contains a host of statistical regularities that can be learned by connectionist systems and babies alike, Seidenberg contends.

Computerized archives of spoken and written language, collected from adults and children, have aided the search for these statistical uniformities. Recurring features of language serve as handy guides to the meaning of spoken or written passages, the USC investigator maintains.

Consider what happens upon being told that "the plane left for the East Coast." Comprehension hinges on a rapid determination that the vehicle meaning of "plane" occurs more often than its other meanings and that the verb "left" more often appears in active rather than passive contexts (such as, "The plane left for the repair crew is missing"). The meaning of "left" is further clarified by noting that "plane" rarely modifies the noun "left," so "the plane left" is not a plausible noun phrase.

Infants wade eagerly into the statistical undercurrents of humanity's verbal stream, according to other research. By 8 months of age, babies use speech regularities as reels with which to fish words out of passing schools of sound, report psychologist Jenny R. Saffran of the University of Rochester (N.Y.) and her coworkers.

Forty-eight babies, all 8 months old, listened to 2 minutes of continuous recorded speech consisting of four three-syllable nonsense words repeated in random order without pauses. A sample of what they heard is "bidaku-padoti-golabu-bidaku." Nonsense words were detectable solely by the tendency of their syllable pairs, such as "bida," to occur together more often than those between words, such as "kupa."

After this brief session, the diminutive participants showed much less interest in listening to the same nonsense words than in listening to new three-syllable words made from the same syllables. Babies tapped into probabilistic information on syllable order in the course of a mere 2 minutes of listening, Saffran's group argues, creating a sense of surprise and interest in new rather than familiar words.

Linguistic learning probably begins with talk overheard from the confines of the womb, Seidenberg holds. In some studies, for example, newborns listen longer to recorded speech in the mother's language than to utterances from another tongue.

Projects such as Saffran's have yet to demonstrate that probabilistic learning unleashes grammatical knowledge. But they do begin to raise questions about the assumption, first articulated by Chomsky, that youngsters could not possibly wield grammar in all its complexity by listening to the often flawed and inconsistent speech of their elders.

"We need to understand the limits of our learning mechanisms before making assumptions about the innateness of language," Seidenberg says.

Connectionist systems are edging toward realistic simulations of how children may attain grammatical milestones through learning, adds psycholinguist Jeffrey L. Elman of the University of California, San Diego. A prime illustration involves the past tense of English verbs.

Researchers reported in 1986 that a simple neural network learned the past tenses of regular and irregular verbs—such as "showed" for "show" and "went" for "go," respectively—in much the same way as has been observed in children. The network was taught to produce correct responses for a small group containing both classes of verbs; soon thereafter, when exposed to a larger sample of unfamiliar verbs, it treated all of them as if they were regular, yielding, say, "bringed" (instead of "brought") for "bring." As these mistakes were corrected one by one, the network gradually improved its ability to produce correct past tenses for irregular verbs that it hadn't specifically been taught.

Pinker, who theorizes that innate grammatical capacities guide the learning of regular past tenses, whereas irregulars must be memorized, criticized this early connectionist foray as artificial and misleading. He noted that the network's designers first trained it on 10 verbs, 8 of which were irregular, and then suddenly exposed it to 410 new verbs, most of which were regular. This arrangement departs sharply from children's actual exposure to verbs during the first few years of life.

An updated neural network, with a more naturalistic exposure to verbs, exhibits many of the subtleties of past-tense acquisition documented in extended studies of preschool children, Elman asserts. As happens with kids, the computer system incorrectly puts "ed" on the end of irregular verbs for a considerable period, but it makes this error for no more than about 10 percent of the irregular verbs in its vocabulary at any one time. It also alternates occasionally between correct and incorrect past tenses for the same irregular verb, in the style of novice talkers.

Elman and his five coauthors describe this system in their 1996 book *Rethinking Innateness* (Cambridge, Mass.: MIT Press).

Such results buttress their opinion that rules and knowledge systems in the

brain arise following neural reorganization due to learning, not from genetic orders independent of childhood experiences. Genes set in motion neural remodeling projects, which must nevertheless operate within the limits of the brain's prespecified structure, Elman holds. Genetic elements interact with one another in ways that are influenced by the types of information available to a growing child, setting off chains of neural events that can play out in a variety of ways and yet still yield specieswide abilities, such as speech.

"Language is a conspiracy of a lot of different forces and factors that did not evolve specifically for language but which come together during development to make language inevitable," Elman holds. "Something about our need

A mother holds her son as he participates in a University of Rochester (N.Y.) language learning study.

to engage in social interactions may predispose us to learn language."

A contrasting perspective on language learning, which has attracted much attention among linguists in the past few years, assumes that children assemble a hierarchy of mental guidelines to unlock possible sentence meanings. All languages are presumed to share these structural themes, which vary in significance from one tongue to another; the challenge for a fledgling communicator is to rank grammatical rules of thumb in a way that best plumbs the meaning of his or her native language.

Optimality theory, as it is known, veers away from Chomsky's emphasis on grammar as a universal set of procedures that, if followed, inevitably clarify conversation.

"Optimality theory provides an account

of how children could figure out their native language, perhaps given innate access to universal constraints on grammar," contends Paul Smolensky, a cognitive scientist at Johns Hopkins University in Baltimore.

Smolensky and linguist Alan Prince of Rutgers University in New Brunswick, N.J., describe optimality theory in the March 14 SCIENCE.

Grammatical constraints for English include the basic word order of subject-verb-object in a sentence and the necessity for all words in a sentence to contribute to its meaning. Yet, constraints may conflict with one another at times, requiring some to take priority over others.

So, for instance, the first word in the sentence "it rains" does not contribute to its meaning, but the expression satisfies the greater need that every sentence must have a subject. Children of English speakers face the task of ranking many such constraints in ways that allow them to wring meaning out of what they hear.

Pinker calls optimality theory an "interesting hybrid" of ideas that he may use in future studies of grammar use. Still, he finds the new wave of connectionist models touted by Elman to be "toy systems with promissory notes that they will eventually learn truly complex grammar."

The biological complexity of the brain also presents vexing hurdles to those intrigued by the nature of language. For instance, a study directed by psychologist Michael Ullman of Georgetown University in Washington, D.C., indicates that separate neural memory systems—one for facts and events, the other for motor skills and habits—underwrite knowledge of words and grammar rules, respectively.
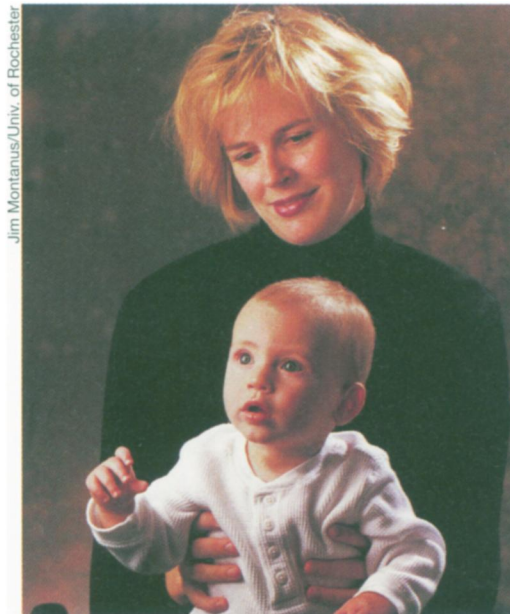
His report, based on vocabulary and grammar tests conducted with people who had suffered brain damage that blocked one or the other type of memory, appears in the March JOURNAL OF COGNITIVE NEUROSCIENCE. Pinker is a coauthor.

Although Ullman accepts Pinker's notion of a language instinct, he acknowledges that the new evidence is more consistent with the theory that wide-ranging brain systems foster linguistic skills.

Both Ullman and Pinker theorize that a language instinct incorporates some brain structures devoted to broad capacities, such as memory, and others that make unique contributions to the use of grammar and words.

Whatever the case, Smolensky views the future of language studies with optimism. "There are moderate views on both sides of the debate," he says. "Fertile ground exists for future research."

Or, as that articulate baby might put it, "Everybody's still talking, I'm still wet and hungry, and Mommy and Daddy are in for a long night." □