Fifty years ago, brain research on language was confined to investigating individuals with brain damage. Today, thanks to technological advances, neuroscientists are using non-invasive methods to examine healthy brain activity of individuals processing language. The plasticity of the human brain, and its potential for learning, is an important discovery of the twentieth century.

Language consists of major subsystems that include sounds, word forms, meanings, structures, and uses in different contexts. Language skills such as listening and reading enable us to comprehend oral and written discourse, whereas speaking and writing enable us to produce oral and written discourse. Linguistic subsystems and language skills do not function in isolation or in a linear and static manner in the brain, but they work in parallel, highly dynamic, interactive, and changeable ways (Friederici, 2012; Kroll & De Groot, 2005; Ullman, 2005).

Understanding how we process the various aspects of language is vital for educators to strengthen teaching and learning in multilingual classrooms today. The brain networks for processing one or more languages differ substantially. In this essay, I examine the neural basis of speech comprehension in monolinguals and discuss some practical applications to facilitate students’ discourse comprehension.

We mostly process language in the left hemisphere of the brain. Linguistic information enters the brain circuitry through the auditory cortex in the temporal lobe when we listen or through the visual cortex in the occipital cortex when we read (See Illustration 1). Wernicke’s area (BA39 and BA40) in the temporal lobe and Broca’s area (BA44 and BA45) in the frontal lobe are considered the classic language areas of the brain. They are inter-connected via various pathways and are both activated for speech comprehension and production. The pre-motor cortex is also activated when we articulate speech.

In a few words, once sounds are processed in the left middle portion of the superior temporal gyrus, words
are recognized and lexical-semantic integration takes place. Then sentential information travels to the frontal lobe for syntactic processing (in BA 44 and frontal operculum) and for further semantic processing (in BA 45 and BA 47) via different pathways. Finally, linguistic information goes back to the temporal lobe for semantic and syntactic integration and optimal sentence comprehension (See Illustration 2). This cycle is highly dynamic and interactive.

Children worldwide acquire their mother tongue within a few years. They fundamentally need to be surrounded by caregivers with whom to interact and use the language to be able to learn it. Brain mechanisms for language learning start operating in infants as early as their gestation period (Dehaene-Lambertz et al. 2002; Klass, 2011). Children acquire vocabulary and meanings (or the lexicon) differently from grammar and syntax (Friederici et al., 2000; Ullman, 2001, 2005). The lexicon is learned in declarative memory sub-served by medial temporal lobe regions (e.g. the hippocampus) and parts of the prefrontal cortex (BA 45 & BA 47). This learning is often explicit and requires attention, conscious processing and memorization. Caregivers play an important role in facilitating children’s acquisition of the lexicon. Grammar and syntax, in contrast, are acquired in procedural memory sub-served by frontal lobe regions such as the pre-motor cortex, Broca’s area (BA 44 and parts of BA 45) and the basal ganglia (sub-cortical structures linked to the frontal cortex). Learning in procedural memory is often automatic, implicit, and almost unconscious (Ullman, 2001, 2005). Thus, children learn their first grammar without training or special instruction.

Adult monolingual speakers also learn new vocabulary and concepts in declarative memory; this learning requires attention, explicit instruction, and memorization. Educators can create classroom activities that promote new vocabulary understanding in meaningful contexts. First, they should raise students’ attention and motivation by presenting the vocabulary in interesting ways. Second, they should present the vocabulary in different contexts and encourage students to make extensive connections with prior learned knowledge and experience. Finally, they should provide ample opportunities for review, practice, repetition, manipulation, and evaluation. Thus, students will activate the brain mechanisms that support lexical-semantic processes, access their internal lexicon and make connections with what they already know, and learn new material.

Procedural memory attenuates with age (Ullman, 2005), but this does not affect adult monolinguals when processing their grammar. They learned it early in life, and they process it automatically and effortlessly. However, if they are to acquire higher levels of literacy, they need to reflect upon and monitor the structures and forms they use and how they use them. Opportunities for noticing, comparing and contrasting, and

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Illustration 2: Brain circuitry for oral sentence comprehension (Friederici, 2012), including the temporal lobe (superior temporal gyrus and middle temporal gyrus) and frontal lobe (inferior frontal gyrus consisting of Broca’s area (BA44 and BA45)). Wernicke’s area (BA39 and BA40), not specified in the image, is a small area in the temporal lobe.
analyzing word forms, structures, and sentence boundaries in meaningful contexts can provide optimal scenarios for students to enhance their meta-cognitive and meta-linguistic skills. In addition to activating the brain mechanisms that support syntactic processing, students will activate the executive function area in the pre-frontal cortex. This area supports general cognition and can enhance students’ meta-linguistic awareness for monitoring language use (Bialystok, 2011; Bialystok et al, 2010).

Brain mechanisms for lexical and syntactic processing are distinct, but complement and support one another in highly dynamic and interactive ways. Linguistic subsystems are inextricably intertwined and should be taught in rich and meaningful literacy contexts. Students should take an active and conscious approach in order to explore these connections.

References


Attend her next workshop “The Neural Bases of Processing One or Two Languages” on November 3, 2016 from 3:15 pm-4:30 pm in Room A-130!

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Mercè Pujol-Ferran is a professor in the Department of Language and Cognition at Hostos Community College. In addition to teaching ESL, she teaches linguistics courses such as “Language Acquisition” and “Introduction to Comparative Linguistics: English and Spanish.” Professor Pujol has published on female contributions to XIX Catalan poetry and on the academic and linguistic challenges of immigrant students in the US. In recent years, Professor Pujol has been studying how the human brain processes language, particularly how bilinguals and multilinguals process more than one language. Professor Pujol has also been an adjunct professor in the Department of Human Development and Cognitive Studies in Education at Teachers College, Columbia University, for a number of semesters. She teaches “The Psychology of Language and Reading.”