Second Language Acquisition:

Considering Cognition and Psycholinguistics to Inform ESL Teaching and Learning

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Abstract

When planning and implementing instruction for English Language Learners, teachers should consider information from outside the field of education. By analyzing research from relevant disciplines, including psycholinguistics, cognitive psychology, and neurolinguistics, teachers can gain a better understanding of students and their ability for second language acquisition (SLA). This paper presents research from each of these fields, and synthesizes this information to present research, implications, and applications for educators, in order to enhance English Language Learners’ language development and content learning.

Keywords: second language acquisition, SLA, English Language Learners, psycholinguistics, neurolinguistics, ESL, education
In recent years, the population of English Language Learners (ELLs) in United States public schools has grown by more than 105%, while the general population has only increased approximately 12% (SouthEast Initiatives Regional Technology in Education Consortium, 2005). Educators must find ways to meet the distinct learning needs of these students and help them reach the level of English proficiency required to learn academic content. When planning and implementing instruction for ELLs, teachers should consider information from outside the field of education. By analyzing research from relevant disciplines, including psycholinguistics, cognitive psychology, and neurolinguistics, teachers can gain a better understanding of students and their ability for second language acquisition (SLA).

This paper will first address the field of neurolinguistics, attending to the history of brain-related research and the effects of advancing neuroimaging technologies. It will next present findings concerning localization of language processes and representations in the brain. Then it will discuss second language acquisition—theories of development, impacting factors, and differences in native and second language neural organization. It will go on to examine psycholinguistics, another field dealing with cognitive research and language, progress of thought within the field, models of language learning, and how the mind deals with language. Finally, the paper will synthesize this information to present research, implications, and applications for educators, in order to enhance ELLs’ language development and content learning.

**Neurolinguistics and Neuroimaging**

The study of language and the brain, or neurolinguistics, dates back to the 1800s, when Paul Broca and Carl Wernicke identified areas of the brain where language is understood and produced. They determined that language functions were localized to areas in the frontal and
temporal lobes—now referred to as Broca’s area and Wernicke’s area, respectively. While these findings are still accepted, thanks to technologies of the twentieth century, neurolinguists have been able to learn much more of how language functions in the brain, and their models of language processing have been modified.

Brain scanning and mapping technologies such as event-related potential (ERP) and Magnetic Resonance Imaging (MRI) allow researchers to more efficiently study complex brain processes, including language comprehension and production. Studies using these technologies have revealed that language processing is more complicated and spread over a large area of the brain in contrast to Broca and Wernicke’s initial propositions (Goldstein, 2011). Research in the area of cognition, including the connection to language, experienced substantial growth in the 1990s. Relating to this surge in studies was the development of functional Magnetic Resonance Imaging (fMRI), which has broadened the field of neurolinguistics and further allowed researchers to discover how we process language and learn. An fMRI is a non-invasive brain scan that emits low levels of radiation, making fMRI more accessible and easier to use than previous systems. During fMRI, activity is measured by detecting changes in deoxyhemoglobin within the brain as a stimulus is presented (i.e. language). Another type of functional imaging is positron emission tomography (PET), which measures changes in blood flow caused when a working area requires increased amounts of blood (Stowe & Sabourin, 1999). By following the blood flow, researchers are able to see which areas of the brain are activated and respond to the stimulus (Sabourin, 2009).

A major benefit of neuroimaging is the ability to test non-damaged brains, which was not a possibility before these technologies were developed (Sabourin, 2009). Additionally, neuroimaging technologies are not constrained to one area of the brain, but a network, using
distributed processing, across both hemispheres and subcortical structures can be seen (Wattendorf & Festman, 2008). In the past, results from fMRI caused frustration among researchers who could not make accurate statements about one person’s brain function based on other studies and information, because no two brains are identical. Recent developments have helped to tackle the issue. A new “atlas” of the brain has been compiled, with more than 7,000 images from four continents that map brain functions including speech and language. Although new technologies are helping advance research in neurolinguistics and education, it is necessary to connect studies with real-world applications and ensure conclusions are relevant and beneficial in the classroom (eSchool Media, Inc., 2011).

**Language in the Brain**

In each area of study, it is necessary to understand how language is stored, produced, comprehended and represented in the brain. Theories of neural organization of language have been led by the findings of Broca and Wernicke, as well as Joseph Jules Dejerine, who proposed the angular gyrus, was also involved in language. Their research identified definite cerebral areas in the left hemisphere necessary for language perception and production. The utilization of neuroimaging technologies has allowed researchers to look more efficiently into a healthy brain. While researchers have further confirmed that Broca, Wernicke, and Dejerine were correct in their submissions, they have found other areas of the brain that are essential to language. Contradictory to the notion that language areas were well circumscribed and homogenous, it is now believed that the language centers are small focal areas not located within a defined space (Neville & Bavelier, 1998).

Thanks to neuroimaging technologies (i.e. fMRI and PET) researchers have been able to see how linguistic functions operate in the human brain. Language processing involves a network
of interacting functions: language memory, sensory input, and motor output (Wattendorf & Festman, 2008). Wattendorf and Festman cite several sources regarding the general localization of language processing functions. One component of language memory includes words we know, what they mean, the sounds (phonemes) that make up words, and how the words can be used, all part of our lexicon (Goldstein, 2011). They conclude that language memory involves the inferior and middle left temporal lobe. Sensory input related to language processing activates areas of the temporal and parietal lobes, including Wernicke’s area. Areas of the brain that support motor output and speech production are the prefrontal and frontal region, including Broca’s area, as well as insula found in the cerebral cortex (Wattenendorf & Festman, 2008).

Researchers are now able to study the subcomponents and specific processes of language. Word processing is spread across areas of the frontal lobe. The left inferior-frontal gyrus and nearby pre-motor areas are involved in semantic and phonological processing; middle, superior and anterior regions are associated with semantic processing and semantic memory. Research suggests the frontal lobe is involved due to various factors required for word processing, including vocabulary access, semantic processing, and short-term phonological storage. There is distinction in auditory and visual (i.e. reading) word processing. Auditory processing activated the left temporal lobe, while visual word processing occurred in areas of the left temporal and supramarginal gyrus, as well as the cerebellum. Although different areas of the brain are activated, the pattern for processing is similar and had led researchers to state that language input visually is transformed into phonological forms in the first steps of processing. Processing sentences is a unique progression that activates Broca’s and Wernicke’s areas, also referred to as the classical language areas. This is due to syntactic processing and phonological processing,
respectively. Research has shown the temporal lobe to be active during sentence processing as well. (Gernsbacher & Kaschak, 2003).

**Second Language Acquisition**

Second language acquisition (SLA) is the process of learning a language (referred to as L2) after one’s first language (referred to as L1) is already established. Various factors can affect SLA, such as age, L1 proficiency, educational background and cognitive abilities (Dixon et al., 2012; Sabourin, 2009; Perani & Abutaledi, 2005). Neuroimaging technologies have also presented opportunities for research in SLA, by considering localization of first and second languages, how plasticity of the brain affects language learning, and the acquisition processes of L1 versus L2 (Sabourin, 2009).

There is significant research on the differences in L1 and L2 representation in the brain. Researchers aim to discover if the learner’s second, developing language is located in overlapping or separate areas of the brain. They have also attempted to discover the relationship between L2 processing and L1 processing. It has been determined that neural mapping of language in the bilingual brain is impacted by several variables, including age of acquisition and language proficiency. (Perani & Abutaledi, 2005).

It is assumed by many in the field that there is a “critical period” (typically, until age 7) for acquiring language; therefore age is an important factor in neural organization. The critical period is based on the concept that the plasticity of the brain decreases with age, and consequently different structures must be used for L2 processing (Stowe & Sabourin, 1999). A person who acquires L2 after the critical period is considered a “late bilingual.” When L2 is learned after the critical period grammatical knowledge becomes explicit memory, whereas L1 knowledge is implicit memory. Explicit memory is the conscious recall of information and is
supported by the left temporal language areas. Implicit memory is recalled unintentionally and automatically and is based in the left frontal-basal ganglia. This has led to hypotheses that the same neural structures cannot be used to process both L1 and L2. Neuroimaging technology has expanded on this idea and has shown that late bilinguals require the activation of additional neural structures in order to complete grammatical tasks in L2, however processing is similar to L1 grammatical tasks (Perani & Abutaledi, 2005). The assumption that L1 and L2 functions do not overlap in the brain is much debated among researchers. Taking into consideration opposing ideas, the most acceptable theory is that late bilinguals’ L2 activates the same neural structures as L1, but these alone are not sufficient to support the acquisition of L2 (Stowe & Sabourin, 1999).

Language proficiency is more influential in the neural organization of L2. When second language is still in early development, there is a dependence on relating L2 to L1. As proficiency increases, L2 processing functions independently and the neural representations begin to resemble that of L1. Studies using neuroimaging have shown that as L2 proficiency approaches the same level as L1, activation within the same structures of the left hemisphere is similar. When L2 proficiency was not comparable to L1, once again it was found that additional neural resources, mostly in prefrontal areas, were required to process the developing language (Perani & Abutaledi, 2005).

Stowe and Sabourin (1999) presented that while the same structures are mostly involved in processing of L1 and L2, the degree of activation varies between the two. Through their analysis of current studies, they have concluded that it is more difficult to process L2 and activation is increased in the classical language areas (Broca’s and Wernicke’s). They hypothesize that some aspects of L2 processing are not optimally carried out within the language
structures of L2 learners’ brains, the systems for language are not utilized efficiently, and some areas are over- and underused to process L2.

**Psycholinguistics**

Another area of research concerning language and the brain is psycholinguistics. Where neurolinguistics is the relationship between language and the structure and functions of the brain, psycholinguistics is the study of language and related psychological processes, attempting to define the how the brain handles, acquires, and processes language (Field, 2008; Goldstein, 2011). Noam Chomksy, one of the most prominent psycholinguists, proposed in the 1950s that the human brain is programmed to acquire and use language. This idea clashed with the previously well-regarded theory of B.F. Skinner, who believed language learning was based on Behaviorism. Skinner stated that children develop language as a result of positive and negative reinforcement. Chomsky criticized Skinner’s work *Verbal Behavior* (1957) and behaviorists’ neglect of the mind. This led to change in the field of psycholinguistics, and focused thought and research on cognition and the mind. Psycholinguists aim to explain internal processes that result in language acquisition. They do this by examining linguistic behaviors and task performance.

From psycholinguistic studies, researchers now understand how a second (or third, fourth, etc.) language acquisition is structured in the mind (Dixon et al., 2012). Recent psycholinguistic research in second language acquisition focuses on how ELLs coordinate two languages, how the new language is constructed in relation to the first language, and the relationship of the two languages (Field, 2008b).

Dixon et al. (2012) highlight theories, distinct and interrelated, psycholinguists have proposed that describe second language learning. Connectionist models, drawing on observational and neuroimaging research, emphasize the importance of input. Ellis and
Seidenberg (as cited in Dixon et al., 2012) state that language input functions as the examples students need to build strong connections between linguistic rules and performance. Additionally, it is important to note that ELLs’ comprehension of input is often incomplete or limited; therefore researchers aim to discover what parts of language, functional or content words, learners struggle with more frequently (Field, 2008a, p. 411). Another model claims L1 and L2 are acquired with similar processes. This unified model states L2 learning relies on information from L1 and that connections are based on the L1 system. From these theories, it can be inferred that an ELL’s first language knowledge and abilities play an important role in developing a second language; and language presented to students in the classroom and during instruction will influence their development of English (Dixon et al., 2012; Nelson, 2013).

Several works have criticized the connectionist view of L2 acquisition (Dixon et al., 2012), but Nelson (2013) asserts that a mature connectionist SLA framework has been reached thanks to thorough psycholinguistic research and practical integration of concepts. Psycholinguists have begun to work with neuropsychologists employing neuroimaging technologies to reach comprehensive results by examining complex language processes (Dixon et al., 2012). Research in the areas of psycholinguistics—comprehension, production, representation, and acquisition (Goldstein, 2011)—can help us to understand how the brain is involved in each aspect of language and inform English language instruction.

**Implications for Educators**

There has been a great deal of research in the areas of second language acquisition, neurolinguistics, and psycholinguistics in recent decades. However, educators must integrate information from these areas to meet the needs of ELLs. As discussed, the brain is a complex organ and is able to complete many tasks simultaneously; therefore we should approach
language teaching addressing the complex processes with multifaceted instruction (Dixon et al., 2012). From research concerning the organization of language and processing in the brain, educators can take away that ELLs will be more successful in oral fluency, vocabulary and literacy than on grammatical or pronunciation tasks. However, it is important to realize that struggles in these areas are less likely to have detrimental effects on overall academic progress. Also, educators must reject the assumption that late English learners cannot succeed in achieving high levels of English proficiency or succeed academically (Dixon et al., 2012). While there are some researchers who believe the “critical” period is the only window of opportunity for learning language, there are not sufficient findings that prove this exclusively (Wattendorf & Festman, 2008); and with proper measures and dedication of educators, “late” ELLs can succeed academically in English (Dixon et al., 2012).

Educators can take research from neurolinguistics to create an improved learning environment for ELLs. Brain mapping technologies have helped researchers to facilitate optimal learning. Now, there is research backing the conditions and learning styles that are most effective for particular kinds of students (eschool Media, Inc., 2011). Cooperating university faculty and researchers have provided some technological and methodical answers to improve language learning. They propose providing intensive intervention to improve the cognitive and linguistic attributes students use to learn language. They also conceived the idea that acoustically modified speech technology can help develop critical language skills. Fast ForWord, a company that develops educational resources, had laid out some basic ideas of how the brain learns, which can enhance ESL instruction. Important skills need to be taught and repeated with appropriate frequency and intensity. Instruction must occur at a skill level that challenges the student, but does not cause frustration. Various skills should be “cross-trained” to maximize achievement.
Finally, they present the following qualities of the learning environment that support learning and promote successful students: students feel psychologically safe in the learning environment and therefore are more likely to take risks, students continue to feel motivated if rewards progress as they do, and content must be engaging for all students (eSchool Media, Inc., 2011).

ELLs’ working memory (WM) and cognitive load (CL) are important aspects within their capacity to learn language and content. Instruction should take into account cognitive load theory (CLT) and address language barriers, which might lead to increased problems with cognitive overload. CLT asserts that learners’ WM has a limited capacity and CL should be managed to increase learning. Managing cognitive load requires attention to each aspect that requires the mind’s attention—intrinsic, nature of material and task; extraneous, effort required to process instruction; and germane, effort contributed to building schema (Kirschner, 2002). In addition to limited school background, a likely possibility with many ELLs, and less content knowledge to draw on (Miller & Endo, 2004), students’ WM is further burdened by language processing simultaneous to learning content. Educators should monitor their language use to ease language load (Miller & Endo, 2004) and attempt to reduce cognitive load by employing research-based practices in the classroom. Szpara and Ahmad (2007) suggest strategies, implemented successfully by teachers in their study, to reduce language cognitive load for ELLs to allow for better content understanding, including: allow students adequate time to process language, think about information, and plan response, rephrase using short and more syntactically simple language, avoid English idioms or abstract language, provide written supplements for essential oral information, and use students’ L1 when possible to increase comprehensibility. Miller and Endo (2004) provide additional strategies, such as rewriting or restating challenging text in simpler language, explicitly defining difficult content terms, and modeling academic language
with supportive visual information and context clues. All of these can help decrease extraneous CL, which allow for more germane CL. Furthermore, Peter Skehan (2006) reverses this idea and proposes that extraneous CL related to content material should be decreased allowing greater attention to respond to linguistic demands. He suggests introducing material, activating prior knowledge and building schema to ease cognitive load and release WM capacity for processing language.

Providing a great deal of language input can stimulate students’ English development (Dixon et al., 2012; eSchool Media, Inc., 2011). English exposure in the classroom is particularly important for ELLs because they have not been subjected to English in their home environment to the same degree as native speakers. The authors of The Science of Learning (eSchool Media, Inc., 2011) describe the importance of language exposure and the related research. Areas of the brain involved in language processing are connected by a pathway that allows association of letters and sounds. According to Martha Burns (as cited in eSchool Media, Inc., 2011):

The brain builds based on what it does. So children who have lots of language exposure build this pathway very precisely… If that [pathway] is weak, that doesn’t mean the child doesn’t have potential… [but] that it hasn’t been exercised as much. (p. 33)

A weak pathway makes it difficult for students to learn grammar, therefore it is important to provide input that provides examples of quality language and target structure (eSchool Media, Inc., 2011; Ellis, 2006). Burns further states, “If you get [the underlying processes] in shape so that a child can learn and benefit from classroom instruction, it can boost all academic areas” (eSchool Media, Inc., 2011, p. 33). Psycholinguists and educational researchers emphasize the
importance of ELLs’ interaction with English in speed of language acquisition and proficiency (Dixon et al., 2012).

Finally, it is suggested that incorporating multimedia technology into instruction results in convergence, simultaneous content and sensory input, which increases retrieval abilities. The Metiri Group (as cited in eSchool Media, Inc., 2011) presented the multimedia principle, which states that memory retention is improved when instruction includes multimodal elements, such as words and pictures, compared with text alone. However, teachers should be cautious of cognitive overload, due to excess amounts of sensory input, and ensure multimedia technology is used appropriately and judiciously.

English language learners face various issues as they attempt to succeed in mainstream classrooms and English dominant environments, including linguistic barriers, cultural differences, curriculum challenges, and general anxiety caused by these factors (Miller & Endo, 2004). It is critical that teachers do everything in their power to help ELLs meet these challenges, develop their English proficiency, and succeed academically. Educators need to seek out and examine research of strategies from various fields to gain a comprehensive understanding of their students’ needs, abilities, and potentials (Dixon et al., 2012).

Conclusion

Neurolinguistics has progressed very quickly in a relatively short amount of time. Much of what we know concerning cognitive processes is based on research carried out with animals; however humans are the only species capable of advanced language. Before the development of brain imaging technology, it was not possible to accurately study the function of language in the brain. Thanks to MRI, fMRI, PET and other indispensable, innovative technological developments we are able to see, literally, how language travels through the brain as it is
processed and understood. In order to utilize the research that is available, I believe educational researchers must integrate information from psycholinguists and neurolinguists, then provide their conclusions to schools and educators who can apply to the research to real-world classrooms. Neurolinguistics research, along with information from psycholinguistics, can greatly help educators of ELLs create instructional programs and strategies that enhance students’ second language acquisition.
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