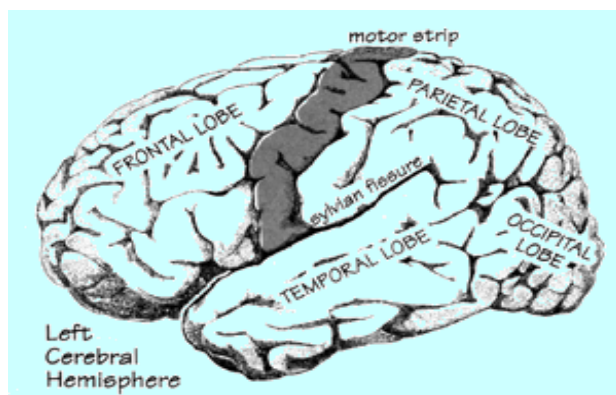


Neuro(bio)linguistics and Applied Linguistics

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I don't see any principled way to distinguish linguistics from neurolinguistics any more than one can distinguish chemistry from physical chemistry in principle. These may be useful distinctions for temporary purposes, but one looks forward to erosion of such boundaries as understanding progresses. My own view has always been that the part of the study of language relevant here is in principle part of human biology: 'biolinguistics', as some have called it"

Noam Chomsky, interview with Brigitte Stemmer, *Brain and Language*
68, 393-401 (1999)

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ABSTRACT

The purpose of the present study is to investigate the role of neuro-biolinguistics in researches done on applied linguistics. In order to find the interaction of the two mentioned disciplines, the place of language in the brain, the development of the brain and its impact on teaching and learning, and differences in brain structure and functioning across different people are dealt with. Finally, a neurobiological perspective on theories of applied linguistics is brought forth where seven controversial questions in applied linguistics related to neuro-biolinguistics are investigated.

What is Neurobiology?

As Portfors (2002) puts it, neurobiology is the study of the nervous system and encompasses research done in animals as well as humans, stretching from the roles of individual molecules in neural function to the expression of neural activity as behavior. He believes that the ultimate goal of neurobiological research is to understand how the nervous system carries out its function.

What is Neuro-(bio)linguistics?

Where in your brain is a word that you've learned? If you know two languages, are they stored in two different parts of your brain? Is the left side of your brain really the language side? If you lose the ability to talk because of a stroke, can you learn to talk again? If you're dyslexic, is your brain different from the brain of someone who has no trouble reading?

According to Menn (1995), all of the above questions are what neuro(bio)linguistics is about.

As Obler & Gjerlow (1999) put it, while the term “neuro(bio)linguistics” is relatively new, the field can be traced back to the nineteenth century when some physicians such as Paul Broca opened up the field with their observations of correlations between language disturbance resulting from brain damage and the particularities of the brain damage that resulted in it. They go on to state that in that century, neuro(bio)linguistics was in the process of distinguishing itself from phrenology (the linking of human characteristics such as “amativeness”- presumably the ability to love – with the relative size of skull areas, and psychiatry; that is, the study of mental illness. They elsewhere state that in recent neurology, the objects of study are the gross areas of brain structure whose primary division was between external surface (cortex), which appeared to have most to do with language, and the larger internal space (subcortical areas) that appeared to have markedly less to do with language.

Where Is Language in the Brain?

According to Menn (1995), brain activity is like the activity of a huge city. A city is organized so that people who live in it can get what they need to live on, but you can't say that a complex activity, like manufacturing a product, is 'in' one place. Raw materials have to arrive, subcontractors are needed, the product must be shipped out in various directions. It's the same with our brains. We can't say that all of language is 'in' a particular part of the brain; it's not even true that a particular word is 'in' just one spot in a person's brain. But we can say

that listening, understanding, talking, and reading each involve activities in certain parts of the brain much more than other parts.

Most of these parts are in the left side of your brain, the left hemisphere, regardless of what language you read and how it is written. We know this because aphasia (language loss due to brain damage) is almost always due to left hemisphere injury. But areas in the right side are essential for communicating effectively and for understanding the point of what people are saying. If you are bilingual, your right hemisphere may be somewhat more involved in your second language than it is in your first language. (Menn, 1995)

Brain Development: Can Teaching Make a Difference?

According to Genesee (2000), it has long been known that different regions of the brain have specialized functions. For example, the frontal lobes are involved in abstract reasoning and planning, while the posterior lobes are involved in vision. Until recently, it was believed that these specialized regions developed from a genetic blueprint that determined the structure and function of specific areas of the brain. That is, particular areas of the brain were designed for processing certain kinds of information from birth.

He further states that new evidence suggests that the brain is much more flexible than previously thought as recent findings indicate that the specialized functions of specific regions of the brain are not fixed at birth but are shaped by experience and learning. To use a computer analogy, he says, we now think that the young brain is like a computer with incredibly sophisticated hardwiring, but no software. The software of the brain, like the software of desktop computers, harnesses the exceptional processing capacity of the brain in the

service of specialized functions, like vision, smell, and language. All individuals have to acquire or develop their own software in order to control the processing power of the brain with which they are born.

A number of studies support this view. However, all were carried out on animals, because it is not possible to do such research with humans. Caution is called for when extrapolating these findings to humans. The studies discussed below reveal the incredible neural flexibility of the developing (and aging) brain. (Genesee, 2000).

Cortical tissue transplanted from its original location to a new location in the brain of young animals takes on the structure and function of its new location and not those of its original location. More specifically, neurons in the visual cortex of rodents have been transplanted to regions of the brain that are normally linked to bodily and sensory functions. The transplanted tissue comes to function like somato-sensory neurons and loses the capacity to process visual information (O'Leary & Stanfield, 1985 cited in Genesee 2000). Likewise, if input from the eyes is redirected from what would normally be the visual area of the brain to what is normally the auditory area of the brain, the area receiving the visual input develops the capacity to process visual and not auditory information. In other words, it is the input that determines the function of specific areas of the brain (Sur, Pallas, & Roe, 1990 cited in Genesee 2000).

Genesee (2000) maintains that Greenenough, Black, and Wallace (1993) have shown synaptic growth in young and aging rats raised in complex environments, and Karni et al. (1995) have shown expansion of cortical involvement in performance of motor tasks following additional learning. In other words, the cortical map can change even in adulthood in response to enriched environmental or learning experiences.

He holds that these findings may have implications for language educators: for one thing, that teaching and teachers can make a difference in brain development. It is worth mentioning that the brain development resulting from teaching is in the software of the brain since according to Strack (2002), the overall shape of the brain is genetically determined (i. e. the hardware of the brain) but various neural connections in different people make each brain unique. (i. e. the software of the brain). Secondly, they shouldn't give up on older language learners.

Learning Through Connections

According to Genesee (2000), the understanding that the brain has areas of specialization has brought with it the tendency to teach in ways that reflect these specialized functions. For example, research concerning the specialized functions of the left and right hemispheres has led to left and right hemisphere teaching. He claims that recent research suggests that such an approach does not reflect how the brain learns, nor how it functions once learning has occurred. To the contrary, "in most higher vertebrates (humans), brain systems interact together as a whole brain with the external world" (Elman et al., 1997, p. 340 cited in Genesee 2000). He states that learning by the brain is about making connections within the brain, and between the brain and the outside world.

What does this mean? Genesee (2000) maintains that until recently, the idea that the neural basis for learning resided in connections between neurons remained speculation. Now, there is direct evidence that when learning occurs, neuro-chemical communication between neurons is facilitated, and less input is

required to activate established connections over time. New evidence also indicates that learning creates connections between not only adjacent neurons but also between distant neurons, and that connections are made from simple circuits to complex ones and from complex circuits to simple ones.

For example, exposure to unfamiliar speech sounds is initially registered by the brain as undifferentiated neural activity. Neural activity is diffuse, because the brain has not learned the acoustic patterns that distinguish one sound from another. As exposure continues, the listener (and the brain) learns to differentiate among different sounds and even among short sequences of sounds that correspond to words or parts of words. Neural connections that reflect this learning process are formed in the auditory (temporal) cortex of the left hemisphere for most individuals. With further exposure, both the simple and complex circuits (corresponding to simple sounds and sequences of sounds) are activated at virtually the same time and more easily. (Genesee, 2000).

Genesee (2000) continues to state that as connections are formed among adjacent neurons to form circuits, connections also begin to form with neurons in other regions of the brain that are associated with visual, tactile, and even olfactory information related to the sound of the word. These connections give the sound of the word meaning. Some of the brain sites for these other neurons are far from the neural circuits that correspond to the component sounds of the words; they include sites in other areas of the left hemisphere and even sites in the right hemisphere. The whole complex of interconnected neurons that are activated by the word is called a neural network. The flow of neural activity is not unidirectional, from simple to complex; it also goes from complex to simple. He states that

simple to complex is the same as bottom-up processing and complex to simple is the same as top-down processing.

He claims that:

Arguments for teaching simple skills in isolation assume that learners can only initially handle simple information and that the use of simple skills in more complex ways should proceed slowly and progressively. Brain research indicates that higher order brain centers that process complex, abstract information can activate and interact with lower order centers, as well as vice versa. (Genesee 2000: 3).

He also exemplifies his contention in the following way:

The flow of neural activity is not unidirectional, from simple to complex; it also goes from complex to simple. For example, higher order neural circuits that are activated by contextual information associated with the word *doggie* can prime the lower order circuit associated with the sound *doggie* with the result that the word *doggie* can be retrieved with little direct input. Complex circuits can be activated at the same time as simple circuits, because the brain is receiving input from multiple external sources such as auditory, visual, spatial, and motor. At the same time that the auditory circuit for the word *doggie* is activated, the visual circuit associated with the sight of a dog is also activated. Simultaneous activation of circuits in different areas of the brain is called parallel processing.

Complex circuits can be activated at the same time as simple circuits, because the brain is receiving input from multiple external sources; auditory, visual, spatial, and motor. At the same time that the auditory circuit for a word is activated, the visual circuit associated

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According to Genesee (2000), in early stages of learning, neural circuits are activated incompletely, and weakly. It is like getting a glimpse of a partially exposed and very blurry photo. With more experience, practice, and exposure, the picture becomes clearer and more detailed. As exposure is repeated, less input is needed to activate the entire network. With time, activation and recognition are relatively automatic, and the learner can direct his attention to other parts of the task. This also explains why learning takes time. Time is needed to establish new neural networks and connections between networks. Learning is a process that establishes new connections among networks, and the new skills or knowledge that are learned are neural circuits and networks.

Now, what are the implications of these findings for teaching? Genesee (2000) believes that first, effective teaching should include a focus on both parts and whole. Instructional approaches that advocate teaching parts and not whole or whole and not parts are misguided, because the brain naturally links local neural activity to circuits that are related to different experiential domains. Second, and related to the preceding point, teaching (and learning) can proceed from the simple to complex and from the complex to simple. Arguments for teaching simple skills in isolation assume that learners can only initially handle simple information and that the use of simple skills in more complex ways should proceed slowly and progressively. Brain research indicates that higher order brain centers that process complex, abstract information can activate and interact with lower order centers, as well as vice versa. For example, teaching students simple emotional expressions (vocabulary and idioms) can take place in the context of talking about different emotions and what situations

elicit different emotions. Students' vocabulary acquisition can be enhanced when it is embedded in real-world complex contexts that are familiar to them. Third, students need time and experience (practice) to consolidate new skills and knowledge to become fluent and articulated.

Are All Brains the Same?

Genesee (2000) believes that brains are not all the same. For most individuals, the left hemisphere is critically involved in most normal language functions. We know this because damage to the left hemisphere in adults leads to language impairment, which is often permanent. However, approximately 10% of normal right-handed individuals have a different pattern of lateralization; their right hemispheres or both hemispheres play a critical role in language (Banich, 1997 cited in Genesee, 2000). Males and females have somewhat different patterns of lateralization, with males being more left-hemisphere dominant than females. In the domain of reading, brain maps of students with dyslexia demonstrate that there are very large individual differences in the areas of the brain that underlie their difficulties (Bigler, 1992 cited in Genesee, 2000).

Genesee (2000) maintains that the areas of the brain that are important in specific domains of learning can change over the life span. There is increasing evidence of right hemisphere involvement in early language learning but less in later learning. Young children with lesions to their right hemisphere demonstrate delays in word comprehension and the use of symbolic and communicative gestures. These problems are not found in adults with right hemisphere lesions. Stiles and Thal have argued that there may be a link between the word

comprehension problems of children and the right hemisphere, because to understand the meaning of a new word, children have to integrate information from many different sources. These sources include acoustic input, but they also include visual information, tactile information, memories of the immediately preceding context, emotions; in short, a range of experiences that define the initial meaning of a word and refine that meaning over time. (Stiles and Thal, as cited in Genesee 2000). We know from a variety of sources that integration across domains of experience is a right-hemisphere function. (Genesee, 2000).

Genesee (2000) concludes here that by implication, brain research confirms what we know from education research: that educators must make provisions for individual differences in learning styles by providing different grouping arrangements, instructional materials, time frames, and so on. Instruction for beginning language learners, in particular, should take into account their need for context-rich, meaningful environments. Individual differences in learning style may not be a simple matter of personal preference, but rather of individual differences in the hardwiring of the brain and, thus, beyond individual control.

Theories of Learning in Applied Linguistics: A Neurobiological Perspective

According to Strack (2002), when empirical evidence does not match with linguistic theory, it is difficult to resolve the disparities. A neurobiological understanding of language processing can offer perspectives that may help to solve some apparent contradictions, both for language learning, and with respect to other related issues in which

such conflict occurs. He believes that applied linguistics is presently facing just such an identity crisis. Peter Skehan points to the uneasy relationship of theory and pedagogy, noting that pedagogical applications derived from theoretical approaches are not properly rooted in theory. (Skehan 1998 cited in Strack, 2002).

Neurobiological knowledge could be used to strengthen the findings of applied linguistics and mediate the conflicts when evidence from psycholinguistic research does not correlate with linguistic theory. There is a cognitive tradition in applied linguistics, but this tradition has drawn more from psycholinguistics than neurobiology. Although neurobiological issues have attracted sporadic attention, (e.g. Jacobs and Schumann 1992), cognitive scientist and linguist Sydney Lamb notes, for most linguists the orientation of neurocognitive linguistics is still new and unfamiliar, even while the term 'cognitive' is being used with ever greater frequency. (Strack, 2002).

Now we are going to focus in detail on the biological processes that underpin language learning, and show how neurobiological insight may help resolve some of the apparent contradictions between standard linguistic theory and what is actually observed.

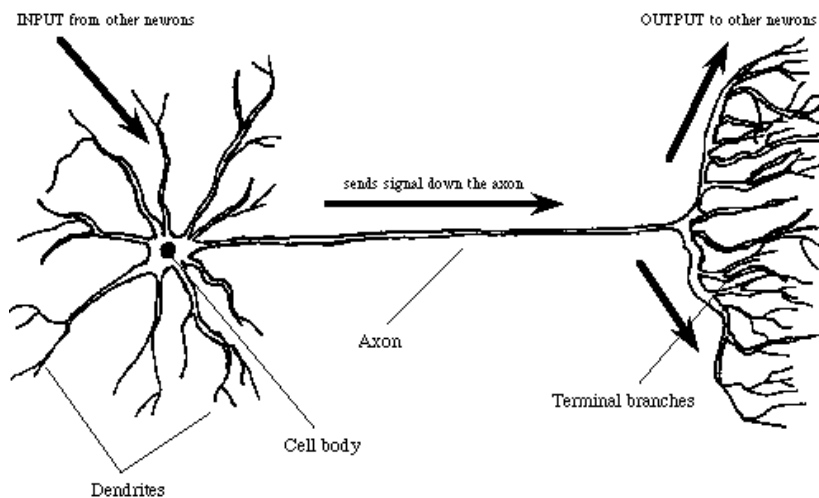
Presuppositions and Conflicting Evidence in Applied Linguistics

1. Is there a critical period in language learning? If there is, how does it work?
2. Is there any biological evidence for a Language Acquisition Device in the brain?

3. Is the brain modular in its processing of language and are the terms associated with modularity biologically meaningful?
4. Is there any neurobiological evidence for either the unity or separation of perception and production?
5. Does neurobiological evidence show any economic necessity to break words down into syllables or segments?
6. Wouldn't it be possible for second language learners to use conventionalized chunks for real communication without utilizing combinatorial analysis?
7. Is there any neurobiological explanation for the way in which both young native speakers and second language learners regress into errors?

(Strack, 2002)

Noticing Neurons: Understanding the Biological Basis of Language



Strack (2002) maintains that specialized cells called neurons form the network that accomplishes the various goals of the body by transmission of electrochemical stimulus. A prototypical neuron has three basic parts: the soma (cell body), the axon (an output fiber) and dendrites (input fibers). Neurons are connected to other neurons and these connections are known as synapses (which usually consist of an axon making contact with the dendrites of another neuron). (Damasio 1999 cited in Strack, 2002). Neurons generate nerve impulses that are called action potentials. (Bear et al 2001 cited in Strack, 2002). According to Bear et al. (2001) cited in Strack (2002), generally being similar to a burning fuse, these electrochemical impulses do not carry information. In response to strong stimulus, a neuron fires rapidly and weak stimulus will produce less frequent or intermittent action potentials. (Edelman 1992 as cited in Strack, 2002).

‘The network of neural subsystems forms according to the basic cellular processes of division, migration, death, adhesion and induction. But, moving and dying in unpredictable ways, are the real driving forces of neural development.’ (Edelman 1992: 60 cited in Strack, 2002). The overall configuration of the brain is genetically determined but from early embryonic stages, neurons extend various branching processes in many directions and connectivity is established at the synapse level as a result of individual development. (Edelman and Tononi 2000 cited in Strack, 2002). Neurons do not simply branch out to complete the system; a mature and functional neural system requires little-used connections to be eliminated while more active connections are strengthened. Edelman has called this selection process *Neural Darwinism*. Deacon (1997) cited in Strack (2002, p.9) notes, ‘nature prefers to overproduce and trim to match, rather than carefully monitor and coordinate the development of cell populations.’

The magnitude of the input stimulus can increase the firing frequency of the action potentials; the more intense the stimulus, the greater the chances that a connection will live and become entrenched. ‘There are two rules of thumb that sum up this neuronal selection process: neurons that fire together, wire together, and neurons that fire out of sync, lose their link’. (Bear et al 2001 cited in Strack, 2002, p. 9).

Linked together, neurons form somewhat localized brain units, but there are no single centers for vision, language, reason or social behavior. There are systems made up of several interconnected brain units. (Damasio 1994 cited in Strack, 2002). Sharp functional distinctions between regions in the cortex do not exist. (Bear et al 2001 cited in Strack, 2002).

In neurological terms, when an object is perceived visually, there is a neural pattern (or mental image) that is registered at various processing stages between the eye and the brain. Mental images need not be visual: auditory images, olfactory images, gustatory images and somatosensory images all leave their marks on the brain in one form or another. (Damasio 1999 cited in Stack, 2002). As mentioned before, these images are not contained in a single action potential. They are formed through the correlation of the action potentials of multiple neurons in the forms of maps. These mappings are not found in a single location of the brain but are distributed over a number of locations. (Damasio 1994 cited in Strack, 2002).

One advantage of the human brain distributed memory system is its relative immunity to catastrophic loss if some neurons die. (Bear et al 2001 cited in Strack, 2002). It is true that drinking alcohol kills neurons, but one drink will not likely cause the drinker to forget the word completely. The highly parallel and redundant nature of mental images assures that it is impossible for one neuron to contain the word

or for a single neuron to allow its access. (Lamb 1999 cited in Strack, 2002). Heavy drinking over a long period of time is another matter, as evidenced by the widespread brain damage often caused by Korsakoff syndrome, a neurological disease associated with chronic alcoholism. (Bear et al 2001 as cited in Strack, 2002). One disadvantage of the highly distributed memory system is relative instability of logic when compared to the specified logical determinacy of systems such as computers. (Edelman 1992 cited in Strack, 2002). Strack (2002) holds that the reason that computers commonly exceed human capacities for chess and mathematical calculation is found in fundamental structural difference rather than memory capacity; the machines were built to be rigorously logical and humans were not.

Each brain is formed in such a way that its wirings are enormously variable at the level of its synapses. It is a selectional system, and each brain is therefore unique. (Edelman and Tononi 2000 cited in Strack, 2002).

Resolving Conflict with Empirical Data: A Neurobiological Approach

1. Is there a critical period in language learning? If there is, how does it work?

As Strack (2002) puts it, from a neurological perspective, there must definitely be a critical period in language learning. Without neuronal branching, the neural system would not exist and without selection and entrenchment, the neural system would not be able to do anything practical. Furthermore, the number of synapses a neuron is capable of sustaining has a limit called synaptic capacity, which

decreases as a neuron matures. Bear et al (2001) cited in Strack (2002) note that in the striate cortex, the synaptic capacity of immature neurons exceeds adult cells by about 50%, and that in macaque monkeys, which are similar to humans in many respects, synaptic capacity in the striate cortex was remarkably constant from infancy until puberty, after which synaptic capacity declined sharply.

According to Stapp, a critical period for first language development is suggested by several types of evidence. For example, human infants are very sensitive to language sounds early in life. Even at the age of 2-3 months, well before language onset, infants are able to discriminate phonemes from any number of languages (Eimas, 1975; Kuhl, 1980, 1981, 1985; Werker and Tees, 1984 cited in Stapp, 1999). This capability gradually declines even in childhood, and by adolescence most individuals experience difficulty discriminating unfamiliar phonemes in foreign languages. (Stapp, 1999).

Other indications of a critical period for language according to Stapp (1999) come from the documentation of language deficiency or impairment as a result of late language development. Incomplete L1 acquisition has been described for cases of brain damage (Ager, Ernhart, Martier, Greene, and Sokol, 1990; Lenneburg, 1967; Vargha-Khadem, Carr, Isaacs, Brett, Adams, and Mishkin, 1997 cited in Stapp, 1999), delayed exposure to sign language for congenitally deaf children (Newport, 1984 cited in Stapp, 1999), and social isolation and neglect in early childhood (Candland, 1993; Curtiss, 1977 cited in Stapp, 1999).

Stapp (1999) maintains that toward the end of the critical period, important changes occur which alter the conditions of neural plasticity and the response to stimuli. Although these factors may continue to operate within the mature system, they take on different functions, and there is no reversion to their previous roles. The neurochemical

conditions of the critical period cannot be revived after the period has lapsed. (Black, 1994; Brown, et al., 1991; Greenough, 1986; Lauder & Krebs, 1986 cited in Stapp, 1999). This functional alteration at the chemical level is one reason why some fundamental neural systems (visual, auditory, cognitive) develop incompletely if they are somehow blocked during the critical period.

Research on monkeys (Cotman & Lynch, 1990; Goldman-Rakic, 1982,1992 cited in Stapp, 1999) and humans (Greenough, 1986; Shatz, 1992; Trevarthen, 1987 cited in Stapp, 1999) indicates that a learning task associated with one cortical region very early in life may be assigned to another cortical area if the same task is learned later on, with the implication that the task is learned somewhat differently depending on when it is learned. Language might be an example. While first language (including simultaneous bilinguality) is densely represented in the language areas of the left hemisphere, a second language acquired later is typically more distributed in the brain (Ojeman and Whitaker, 1978 cited in Stapp, 1999). Recent experiments using functional magnetic resonance imaging (fMRI) have provided new evidence about such neurofunctional patterns of distribution. Investigations by Kim, Relkin, Lee, and Hirsch (1997) confirm that second languages acquired in very early childhood are spatially close to first language in the frontal lobe, while languages acquired later are separated in this region. (Stapp, 1999).

Some scholars such as Greenough, 1986; Greenough, Black and Wallace, 1996; Lauder and Krebs, 1986; Shepherd, 1988 cited in Stapp (1999) believe that neural plasticity is essentially a permanent feature of the brain, ensuring continued adaptation and learning throughout life. However, the same degree of plasticity is not available for all types of learning over a lifetime. While we tend to learn new faces in much the same manner throughout life, some types

of information and skills (like a foreign language) are easier to learn in childhood than in maturity. This is an indication that the availability of plasticity differs across brain functions. Because of the critical period, certain types of learning and experience are compromised by age. The evidence for this is established for the development of sensory and motor systems. The types of experiments used for investigating the development of these systems and cognitive systems of the brain cannot be performed on human subjects. However, it is possible to extrapolate from the available evidence that there are time constraints for a number of brain systems, including cognitive systems such as language.

Other scholars claim that older children and adults actually have an advantage in L2 acquisition over younger children because of superior cognitive skills which they have in the initial stages of L2 acquisition (e.g., Ellis, 1985; Genesee, 1988; Walsh and Diller, 1981 cited in Stapp, 1999). In view of the fact that *ultimate proficiency* is the real issue in second language acquisition, it is important to understand the nature of neural plasticity serving different types of learning. While some type of advantage may exist at some stage for older language learners, their ultimate proficiency is not equal to that of young learners. (Stapp, 1999)

Although delayed acquisition of first language at age five or six is problematic for complete development, the same age is ideal for attainment of native-level second language acquisition (Johnson and Newport, 1989; Long, 1990; Patkowski, 1990; Scovel, 1988; and Seliger, 1978 cited in Stapp, 1999). The type of neural plasticity that at this age facilitates second language seems partially associated with skills involving motor coordination. Phonology and syntax share with certain types of musical, dance and sports training the requirement of early instruction for optimal potential development. The plasticity

associated with finely coordinated motor skills diminishes with maturity. It is likely that this plasticity constraint is responsible for the common experience of foreign accent and the incomplete mastery of the syntax of a second language when learning begins in adolescence or adulthood. (Stapp, 1999).

Walsh and Diller (1981) cited in Brown (1994) state that different aspects of a second language are learned optimally at different ages and that lower-order processes such as pronunciation are dependent on early maturing which makes foreign accent difficult to overcome after childhood. Higher-order language functions such as semantic relations are more dependent on late maturing neural circuits and are learned better in adulthood. So, they believe that there is a neurobiologically-based critical period, but principally for the acquisition of a native-like accent, and not very strongly for the acquisition of communicative fluency and other higher-order processes.

2. Is there any biological evidence for a Language Acquisition Device in the brain?

Kreger (1999) believes that the anti-revolutionists have separated the universal grammar mode of Chomsky from its conceptual basis and have shifted it to a biological basis, even though there was and is no genetic or biological evidence of language rules biologically structured in the brain.

Fromkin (1998: 602) cited in Kreger (1999) also states that the fact that any language ability can be taken up by the right hemisphere in adulthood indicates that a genetically originated structure is unlikely to account for language function and/or acquisition.

Finally, Kreger (1999: 2) maintains that:

“Since Chomsky also insisted "that the extraordinarily rapid acquisition of linguistic competence by human infants and the degree of creativity displayed is so far beyond anything demonstrated by other species that it reveals a *qualitatively distinct* level of cognitive organization" (Goodwin 1994: 100; emphasis added), Universal Grammar became a *qualitatively distinct* trait used to define *H. sapiens* as a species. This distinction led the Universal Grammar model of Chomsky to be separated from its conceptual basis, and shifted to a biological basis by anti-evolutionists, even though there was and is no genetic or biological evidence of language rules somehow biologically structured in the brain.”

As Strack (2002) puts it, all of the neuroscientists mentioned agreed that the brain, in its entirety, is an excellent language acquisition device, but this fails to respond to the heart of the question. None of the researchers mentioned any structure that could be considered as a LAD. On the contrary, all stressed that phrenology (an emphasis on discrete localized function) is not an option, and that different cognitive skills are distributed throughout the brain various systems. Lamb (1999) cited in Stack (2002) sums things up: there is no reason for supposing that the brain has genetically built-in structures dedicated specifically to language. Although genetically predetermined structures specific to language are not ruled out, until neurobiological proof affords itself, there is no necessity to posit them. Finally, aside from the lack of biological evidence for a LAD, Deacon (1997) cited in Strack (2002) argues that genetic specification of precise neural connections in the brain would be too costly in terms of genetic resources.

According to Strack (2002), learning in the absence of explicit error correction may be explained without hypothesizing an innate LAD. Terry Regier, in his connectionist modeling of spatio-linguistic

understanding states that nature tends to overproduce and trim to fit and the high correlation between his model and actual human language understanding cannot strictly be considered incidental. (Strack, 2002).

3. Is the brain modular in its processing of language and are the terms associated with modularity biologically meaningful?

According to Strack (2002), the modules that Pinker suggests (namely, phonology, lexicon, morphology, syntax and semantics) will not likely to be found in any clearly demarcated form because of the distributed nature of neural processing. Lamb (1999) cited in Strack (2002) echoes this opinion, noting that the linguistic system is not a unified system, but a complex of subsystems that are closely related to one another, although these relationships are not simple ones.

The most likely candidate for modularity would seem to be phonology, in that the primary auditory cortex seems to be adapted specifically for the reception of sound images. However, it processes all kind of sounds, not just language, so it could not strictly be called a phonology module. (Bear et al 2001 cited in Strack, 2002). Can a phonology module that is also capable of processing non-phonological sign language accurately be called a phonology module? Moreover, modules for lexicon, morphology, syntax and semantics are also highly unlikely. (Strack, 2002).

According to Strack (2002), at first glance, different areas of the brain seem to facilitate certain cognitive functions, but the functions do not fall along traditional linguistic lines. Lamb (1999) cited in Strack (2002) states the fact that although the brain is very good at language, it is also good at things other than language. Specifically, Deacon points out:

Though breaking up language analytically into such complementary domains as syntax and semantics, noun and verb, production and comprehension can provide useful categories for the linguist, and breaking it up according to sensory and motor functions seems easier from a global neuronal viewpoint, we should not expect the brain handling of language to follow either of these categorical distinctions. (Deacon 1997: 298 cited in Strack, 2002)

Lamb mentions that analytical linguistics partitions language with respect to taxonomic convenience rather than functional precision. (1999 cited in Strack, 2002).

4. Is there any neurobiological evidence for either the unity or separation of production and perception?

As Strack (2002) puts it, clearly, questions such as this will have great repercussions for a second language learning environment. If the perception and production aspects of language are unified, then student errors in one domain must be caused by some kind of unexplained interference within the modular associations themselves, beyond the student conscious control. In contrast, if the two aspects are separate, then problems with perception or production may potentially be addressed locally and more or less irrespective of the counterpart ability.

Strack (2002) holds that neurobiologically speaking, the two aspects do seem to be somewhat separate, although there must also be some overlap. Incoming sound requires preprocessing in preliminary auditory cortices before moving through the primary auditory cortex to Wernicke area in the brain. In contrast, phonetic coding of meaning for speech begins with association in regions including Broca area, then proceeding to various motor cortices for the initiation of motor

sequences that trigger physical movement of the lungs, vocal chords, tongue and mouth. To the extent that Wernicke area and Broca area stimulate the same conceptual neural maps, there will be a correlation of activity, but there is a great functional difference between a sound image to be interpreted and a motor schema to produce a sound through speech. Regarding this neurobiological dissociation of early sensory and motor cortices, Lamb notes, understanding is perceptual while producing language is a motor activity, like drawing a picture or dancing. If this is so, language has both a production subsystem and perceptual subsystem as separate systems .(Lamb, 1999 cited in Strack, 2002). Since most people can easily repeat words they've just heard, we understand that these correlative connections have indeed been made. So, we can say that the actual functions are not two sides to the same coin; they are two different coins, or more accurately a coin and a machine that can mint a similar coin. (Strack, 2002).

As for written production and oral production, it is worth noting that Hillis, et. al (1999) carried out a research on a neurobiologically impaired patient with striking dissociation between speaking and writing and reported her pattern of performance on language tasks. They held that despite her good performance in spoken production and both written and spoken comprehension, her written production was markedly impaired. Here, we can come to the conclusion that oral and written production are separate, just as production and perception are separate since if the two aspects were in a single place, then the impaired patient under the question had shown difficulty in both oral and written production, but that was not the case. So, oral production is neurobiologically separate from written production.

5. *Does neurobiological evidence show any economic necessity to break words down into syllables or segments?*

The assumption that it is uneconomical for the brain to store different forms of words intact assumes that the brain is strapped for memory resources. Is this an accurate assessment? Edelman (1992) cited in Strack (2002) estimates there are about 1 million billion connections in the cortical sheet, and, in taking into account how these connections might be combined, the number of potential connections would be on the order of ten followed by millions of zero. Damasio's more conservative estimate shows that one human brain contains several billion neurons with at least 10 trillion synapses among these. (Damasio, 1994 cited in Strack, 2002).

For Deacon, however, raw neural capacity is not the decisive issue in answering questions of economy:

“Time is a critically important factor, especially in an information-processing device that tends to operate almost entirely in parallel (instead of funneling all operations through a single processing unit, as do most desktop computers). Maintaining a signal within a circuit long enough to analyze its part in some extended pattern would tend to get in the way of processes that require rapid and precise timing. (Deacon 1997: 292-293 cited in Strack, 2002).”

Lamb (1999) cited in Strack (2002) goes so far as to speculate on the availability of neural wiring over a lifetime. Then he echoes Deacon optimism concerning the brain ample resources, stating that the abundance hypothesis seems to be confirmed. The main neural constraint on language would appear to be processing time rather than memory capacity.

6. *Wouldn't it be possible for second language learners to use conventionalized chunks for real communication without utilizing combinatorial analysis?*

According to Strack (2002), there is strong evidence that some aspects of language become deeply established by frequent repetition in production. These overlearned linguistic items do indeed seem to operate irrespective of grammatical analysis. Bear et al (2001) cited in Strack (2002) note that there are certain overlearned things Broca aphasics can say without much hesitation, such as the days of the week. While Bialystok and others treat this sort of example as an atypical process that may or may not have linguistic value, there is no neurobiological reason to believe that all language is not learned in chunks of varying length and grammatical complexity.

Actually, for some scholars including William Croft (1998) and Adele Goldberg (1995), the observation that foreign language students often attempt to learn language by memorizing large chunks is not in any way problematic; according to their views, it simply shows the way in which language is actually learned. (Strack, 2002).

7. *Is there any neurobiological explanation for the way in which both young native speakers and second language learners regress into errors?*

Deacon (1997) cited in Strack (2002) believes that learning is, at its base, a function of the correlations between things, from the synaptic level to the behavioral level. In this view, learning is characterized by probabilistic correlation rather than precise specification. To put it another way, neural mapping, the basic organizing principle of memory, is association of perception

according to spatio-temporal contiguity, which is not actually logical at all. But the illogicality in the argument form does not stop it from being effective. ‘Neurons that fire together, wire together’ (p. 18), and so logically unrelated aspects of sensory perception can become associated through correlation. Less well-established routines have weaker mutual associations among constituent neurons and therefore a lower statistical probability of being available at the crucial moment. Just because a language item is consistently available does not mean it is being accessed in the same way from one instance to the next. For these reasons, the processing of a sentence is not a short route through a predetermined circuit in a language governing center but a far-reaching and fairly unpredictable resonance among separate brain units in three-dimensional space and time. Therefore, regression into error for both young native speakers and second language learners can be explained in terms of statistical probability. Neural Darwinism brings about bias toward linguistic efficiency; however, until overlearning has occurred, a single correct utterance is no guarantee of future perfection. (Strack, 2002).

To summarize all these, Strack (2002) states that there is indeed a critical period in language learning and it is crucially interrelated with neuronal branching and selection processes. The quick pace of language learning in the absence of explicit error correction may be explained according to basic neuronal processes without reference to language modules or a LAD; indeed, there is no neurobiological evidence to support their existence. Consequently, the terminology often associated with modularity, while analytically useful, may not be biologically meaningful. Although perception and production necessarily overlap in association cortices, motor functions of production and sensory functions of perception are relatively discrete. There is no economic necessity to break words or phrases down to

conserve memory. Not coincidentally, overlearned chunks of language are essentially linguistic in nature and an exemplar-based understanding of language is the most neurally plausible option. Finally, regression into error for children and second language learners can be explained straightforwardly in neural terms by the unstable, probabilistic nature of perception and linguistic association.

Realigning Applied Linguistics to match Neurobiological Processes

According to Strack (2002), Skehan, in his book, *A Cognitive Approach to Applied Linguistics* (1998), calls for a realignment of theory with empirical evidence. He mentions a great number of cases in which theory does not match up well with observation.

Nevertheless, according to Strack (2002), research aiming for a cognitive view of language acquisition cannot hope to account for everything in terms of neural processes. Skehan (1998) cited in Strack (2002) notes that the classroom is a social environment and so affective concerns must also be figured into the equation. But, according to Strack (2002) it is unfortunate that although Skehan book is titled *A Cognitive Approach to Applied Linguistics*, he makes almost no reference to neurobiology. When he advocates a cognitive approach, he explicitly refers to a psycholinguistic approach. Although there is a tendency to equate cognitive with psychological, the findings of psycholinguistic study represent but one portion of the potentially useful evidence that may be brought to bear on perennially intractable problems of applied linguistics. Although psycholinguistic evidence is important and cannot be brushed aside, ultimately, any

theory of language that is not defensible with respect to neurobiology is not a viable theory. (Strack, 2002).

As for the place of psycholinguistics in neurolinguistics, Sekerina (2000) states that historically psycholinguistics started as a discipline uniting the three fields of psychology of adult language, language acquisition, and biological foundations of language. However, in the past 15 years, these fields have branched out into separate, but closely related disciplines; namely, psycholinguistics, acquisition, and neurolinguistics.

He claims that there are some interdisciplinary projects in which psycholinguistics and neurolinguistics both contribute. He states that a comprehensive theory of language performance must simultaneously explain the wide range of phenomenon associated with processing. he continues to state that such theory must be able to account for the various underlying grammatical structures (theoretical linguistics), how language usages affects processing mechanisms (computational linguistics), how language processing is implemented in the brain (neurolinguistics), and how children learn to parse (acquisition and learnability).

Conclusions

According to Strack (2002), theories of language learning are only useful insofar as they detail how language is actually learned. In this way, they facilitate effective learning.

He believes that although knowledge of neurobiology could play a mediating role in the resolution of longstanding disputes, applied linguists have made little reference to the actual electrochemical processes by which language learning is facilitated. A change of

perspective may allow applied linguists freedom to extend the limits of theory, rather than being restrained by it.

At the end it is worth referring to Bialystok (1998) when she claims that applied linguistics can also solve the problems and ambiguities of neurolinguistics. So, we can come to the conclusion that neuro(bio)linguistics is not only a giver to applied linguistics, but also a receiver of the findings and achievements of applied linguistics.

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عصب‌شناسی زبان و زبان‌شناسی کاربردی

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چکیده

هدف تحقیق فعلی بررسی نقش عصب‌شناسی زبان در تحقیقاتی است که در زمینه زبان‌شناسی کاربردی انجام گرفته است. برای یافتن تعامل بین این دو رشته ذکر شده به بررسی جایگاه زبان در مغز، رشد مغز و تأثیر آن بر آموزش و یادگیری و تفاوت‌های موجود در ساختار و عملکرد مغز افراد مختلف خواهیم پرداخت. در پایان، تئوری‌های زبان‌شناسی کاربردی از منظر عصب‌شناسی بررسی خواهند شد و در آنجا هفت سؤال بحث‌برانگیز در زمینه عصب‌شناسی زبان مورد بررسی قرار خواهند گرفت.

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