Brain and Language

Language is separated into motor (speaking) and auditory (hearing) skills. These are linked in a complex way to thinking processes.

Large parts of the human cerebral cortex are language specialised. The localisation of language centres was possible, because one could, in the past, pinpoint language disorders of different kinds in the brain as tissue damage after the death of the patient. The most famous of these patients was a M. Tan who could only pronounce the syllable “tan”, albeit in different accentuations. His physician was the French neuro-anatomist Paul Broca (1824-1880. When he examined the brain of the deceased he could see that the hyper frontal third squirm of the left hemisphere was badly damaged. This still called “Broca centre” is perceived to be the region where language is created. In 1874 the Breslau neurologist Carl Wernicke described the reversed case: patients who can still speak but do not understand the meaning of the spoken word. These patients had a damaged upper squirm of the left temporal lobe. The so called “Wernicke centre” is perceived as the region of speech comprehension.

This separation of language functions still holds today. However, Latest examinations of language impaired patients - recording of the impediment and later autopsy as well as experiments in which the electric stimulation of selective regions resulted in speech impediments - contradict this simple attribution: language functions not only spread over a considerable part of the cerebral cortex, but also effect below the cortex situated regions such as the left, rear thalamus.

Modern technology based on image creations of the brain such as the magnet resonance tomography makes it possible to locate brain activity during cognitive activities. Therefore, one can at least establish a plausible route map which illustrates which centres are involved from the arrival of an acoustic signal to the interpretation of this data in the brain, showing an increased energy metabolism.

When we hear language, the language recognition system in the brain tries initially to comprehend the individual phonetic unit – it conducts an acoustic-phonetic analysis. Parts of the temporal lobe and lower situated regions of the lobe in the left hemisphere examine jointly initially the categories of this data.

The language recognition system therefore decides whether it has encountered a substantive or a verb and recognises in this way the syntax of the received information. Verbs are examined at a different location from substantives. It follows the deciphering of the meaning, the semantics, with the inquiry into sense of meaning of the sentence. Te melody of the sentence, the so called prosodic information is processed in a different region, predominantly in the right hemisphere, that is, in the region which concentrates mainly on emotion. Women are more affected by sentence prosody, men, in contrast, more by semantics. The brain deciphers first grammar and only after that the meaning of the sentence. After the syntax recognition stage, a further network retrieves the word meaning data content. Only after this dual examination become we aware of the information. If the message cannot be interpreted at the first attempt, e.g. because of incorrect grammar, the brain attempts a second try to find an acceptable interpretation of what was heard. This examination with a possible second one can last pro word approx. 600 milliseconds. Since we speak with ca. 600 words per minute, fast speakers are in danger of being heard by their interlocutors, but not understood.

The molecular occurrence, with which what was heard is linked with the following action/activity, is still not understood. Why can activities derive from sentences that we have never heard before? Why can the word “pig” result in the interlocutor’s aggression, while the word “gig”, with only one phoneme changed, can cause a sense of pleasure? Why do we regard what was said spontaneously as correct, something else as questionable and a third as obviously wrong? Historical and social studies have provided numerous attempts to arrive at an explanation. Chemical-physical illustrations how a sound results in activity, does not exist and is unlikely occur in the near future.

Gassen (2008, pp. 109-110)

Gassen’s statement that “this separation of language functions still holds today” (Broca and Wernicke areas) needs qualifying.

Given that Boca’ and Wernicke’s areas mediate different but complementary aspects of language processing, they must be able to interact. A tract of nerve fibres (arcuate fasciculus) directly connects these areas (Geschwind, 1974).

(Schoenemann, 2009)

The evolution of language and the evolution of the brain are tightly interlinked. Language evolution represents a special kind of adaptation, in part because language is a complex behavior (as opposed to a physical feature) but also because changes are adaptive only to the extent that they increase either one’s understanding of others or one’s understanding *to* others. Evolutionary changes in the human brain that are thought to be relevant to language are reviewed. The extent to which these changes are a cause or consequence of language evolution is a good question, but it is argued that the process may best be viewed as a complex adaptive system, in which cultural learning interacts with biology iteratively over time to produce language.
(Schoenemann, 2009)

“Giacomo Rizzalatti, an Italian neuroscientist, has discovered that when a monkey carries out a specific action with its hand, such as putting a peanut in its mouth, certain neurons in the premotor cortex become active. Remarkably, the same neutrons become active when a monkey watches another monkey (or even a person) put food in its mouth. Rizzolatti calls these “mirror neurons” and suggests that they provide the first inside into imitation, identification, empathy, and possibly the ability to mime vocalization-the mental processes intrinsic to human interaction. Vilayanur Ramachandran has found evidence of comparable neurons in the premotor cortex of people” (Kandel, 2006, p. 425)

Aboititz et al (2006) express doubt whether the above is solely responsible for the development of language but are of the opinion that there are/were certain aspects at work which are only found in humans, such as and semantic and syntactic processing. They discuss this in the context of two currently prevailing theories of the origin of language: the mirror system (mirror neurons) and “generative grammar”.

This is heavy stuff for language teachers, but interesting for those who want to know how their subject (language) evolved. The article also gives a good reference list which one can use to compare the different positions.

Corballis (2010) also sees the mirror neurons as instigator of language. The mirror neurons were there from the beginning and it is here where evolution situated the origin of language. He (and others) is of the opinion that language developed from gestures. Mental time travel, and I assume he means memory and thinking into the future, forced the system to “grammaticalise”, involving the evolving vocabulary in thinking about other concepts than just the present, resulting eventual in autonomous speech. He also mentions that we still gesture.

Barry (2009) gives an overview of mirror neuron research so far, concentrating on the cultural effect (the origin of culture and the effect the discovery of mirror neurons has on our culture today. One can easily imagine what these findings can do for the advertising industry (Senior & Rippon, 2007) and politics and politicians (Connolly, 2002), just to give two areas of application. One shudders to think.

She also reports a nice quote from Ramachandran (2000): “Mirror neurons will do for psychology what DNA did for biology.”

Those who want to read more about the mirror neurons and their importance for language development, can access the “Library”. I have included a few books and articles. They have then their own reference sections.

The effect of right and left brain dominance in language learning

“The purpose of this study is to determine the effects of right and left brain dominance on students’ academic achievement and learning English. Language classrooms consist of students who have different learning styles and these learning styles are related with the dominance of right or left brain. This has a great impact during the learning process. Therefore, having an idea about the brain dominance of the students is important. If the teacher knows his or her students well, he or she can use the methods, techniques and materials adequately. This research will provide the teachers to find out the dominant part of their students’ brains and use the appropriate classroom techniques, methods and tools according to them. It will also give the opportunity of finding out the teachers’ brain dominance to help him / her to be aware of his / her teaching style.”
(Oflaz, 2011)

Neurolingistics

Neurolinguistists have provided a plethora of new and interesting research studies on how the human language is represented in the brain and how learning neurologically takes place. However, only a limited number of attempts have been

made to negotiate neurolinguistics with educational sciences and especially with foreign language teaching methods. This paper aims to discuss that if foreign language teaching methodologists examine findings of neurolinguistics, they can find alternative explanations on how to improve the already existent teaching methods or even offer new methods and techniques for more effective instruction.
(Nergis, 2011)

Distinct cortical areas associated with native and second languages

The ability to acquire and use several languages selectively is a unique and essential human capacity. Here we investigate the fundamental question of how multiple languages are represented in a human brain. We applied functional magnetic resonance imaging (fMRI) to determine the spatial relationship between native and second languages in the human cortex, and show that ithin the frontal-lobe language-sensitive regions (Broca's area)1–3, second languages acquired in adulthood ('late' bilingual subjects) are spatially separated from native languages. However, when acquired during the early language acquisition stage of development ('early' bilingual subjects), native and second languages tend to be represented in common frontal cortical areas. In both late and early bilingual subjects, the temporal-lobe language sensitive regions (Wernicke's area)1–3 also show effectively little or no separation of activity based on the age of language acquisition.
This discovery of language-specific regions in Broca's area advances our understanding of the cortical representation that underlies multiple language functions.
(Kim, Relkin, Lee, & Hirsch, 1997)

Right Hemisphere Involvement in Processing Later-Learned Languages in Multilinguals

In two experiments, multilingual Papa New Guinea subjects were tested using a divided visual field technique to determine hemispheric laterality for English and for Tok Pisin. Various factors, including age of acquisition, proficiency, mode of instructiuon, and numbers of years that the language had been used were considered in relation to language laterality. Only age of acquisition proved to be a significant contributor to the laterality effects obtained; older acquirers of both English and Tok Pisin showed greater right hemisphere involvement than early acquirers. Although Proficiency did not seem to be related to language laterality, it too was systematically affected by acquisition age. Older acquirers of English performed significantly poorer than younger acquirers on all of the four language-usage tests given. The strong influence of acquisition age on cerebral laterality for language and proficiency is interpreted as supporting a critical period for language learning.
(Wuillemin & Richardson, 1994)

The neural basis of lexicon and grammar in first and second language: the declarative/procedural model

Theoretical and empirical aspects of the neural bases of the mental lexicon and the mental grammar in first and second language (L1 and L2) are discussed. It is argued that in L1, the learning, representation, and processing of lexicon and grammar depend on two well-studied brain memory systems. According to the declarative/procedural model, lexical memory depends upon declarative memory, which is rooted in temporal lobe structures, and has been implicated in the learning and use of fact and event knowledge. Aspects of grammar are subserved by procedural memory, which is rooted in left frontal/basal-ganglia structures, and has been implicated in the acquisition and expression of motor and cognitive skills and

habits. This view is supported by psycholinguistic and neurolinguistic evidence. In contrast, linguistic forms whose grammatical computation depends upon procedural memory in L1 are posited to be largely dependent upon declarative/lexical memory in L2. They may be either memorized or constructed by explicit rules learned in declarative memory. Thus in L2, such linguistic forms should be less dependent on procedural memory, and more dependent on declarative memory, than in L1. Moreover, this shift to declarative memory is expected to increase with increasing age of exposure to L2, and with less experience (practice) with the language, which is predicted to improve the learning of grammatical rules by procedural memory. A retrospective examination of lesion, neuroimaging, and electrophysiological studies investigating the neural bases of L2 is presented. It is argued that the data from these studies support the predictions of the declarative/procedural model.
(Ullman, 2001)

Large-scale neural network for sentence processing

The authors' model of sentence comprehension includes at least grammatical processes important for structure-building, and executive resources such as working memory that support these grammatical processes. They found activation of the ventral portion of left inferior frontal cortex during judgments of violations of each grammatical feature. Their observations are consistent with a large scale neural network for sentence processing that includes a core set of regions for detecting and repairing several different kinds of grammatical features, and additional regions that appear to participate depending on the working memory demands associated with processing a particular grammatical feature. (Cooke et al., 2006)

APPRAISAL PSYCHOLOGY, NEUROBIOLOGY, AND LANGUAGE

This volume of *The Annual Review of Applied Linguistics* explores the connections between psychology and language. The author shows how a field that increasingly informs psychology can also inform the psychological issues that concern applied linguists. Neurobiology and psychology have become more closely integrated in recent years as evidenced by the emergence and development of such disciplinary interfaces as biopsychology and cognitive neuroscience. The recognition that psychological phenomena are subserved by the brain is widely accepted; via developments in neuroimaging technology, the brain is becoming amenable to direct psychological investigation. The author examines brain mechanisms that are involved in second language acquisition motivation, in cognitive/motor exploratory activity in learning, and in decision-making aspects of pragmatics in language use.
(Schumann, 2001)

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