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Some Aspects of the Biological Bases of Language

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SOME ASPECTS OF THE BIOLOGICAL BASES OF LANGUAGE

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BY
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This is a project which reviews some of the literature dealing with the biological aspects of language. It intends to give the reader who is not familiar with the biology of language an idea of the relevance this subject has to reaching a better understanding of language in general.

This project by Lydia Artiola is accepted in its present form.

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ABSTRACT

A look into language from a biological point of view. Some aspects of language in the central nervous system, concentrating on the brain are presented. Neuroanatomy and neurophysiology of the language system are discussed. A discussion on the applicability of certain biological premises to the language system.

I

INTRODUCTION

Whenever human beings live together they develop a system of communicating with each other; even the most primitive societies use speech. Furthermore we know of no civilization where speech was not available. In fact, the spoken language is one of those few basic abilities -tool making is another- that set us apart from animals and are closely related with our ability to think abstractly.

Why is language so important? One reason is that the development of human civilization is made possible -to a great extent- by man's ability to share experiences, to exchange ideas and to transmit knowledge from one generation to another; in other words, his ability to communicate with other members of his own species. Men have many ways of communication; most people will agree, however, that the spoken language is the system that man has found to be far more efficient and convenient than any other. In addition, language occupies a central position in all of man's intellectual activities. If we understood the nature of language we might be able to unravel some of the most profound mysteries of the relation between the human mind and the human brain.

The study of language is pertinent to many fields of inquiry. It concerns physics, chemistry, biology, psychology, anthropology, sociology, linguistics and history. It embraces the humanities as well as the social and natural sciences. New knowledge is constantly being brought to light- and new fields explored- at a rate that makes it difficult for scientists, engineers and scholars to keep abreast of developments in their own fields, let alone those outside their immediate concern. Language provides an excellent illustration of the interrelation of concepts from a wide range of disciplines, and it shows to advantage what can be gained by using the points of view and methods of investigation of several disciplines.

This paper is concerned with some of the biological aspects of language. It is intended to be read by people who have some knowledge of aspects of language such as linguistics and psycholinguistics, and who would be interested in being introduced to the complexity of the biological aspects of language. It is not my intention to state that language is mainly biological. I believe that the serious student of language should try to familiarize himself with as many fields of inquiry as possible in an integrating manner, so that he may have at least an overall view of the subject matter.

I chose to do some research in the field of biology as a matter of personal interest; furthermore, I believe that an understanding of the basic biology of language is necessary if one intends to study other aspects of this field. Some people will say that it is not necessary to be a mechanic in order to drive a car... but I think it helps when mechanical problems arise.

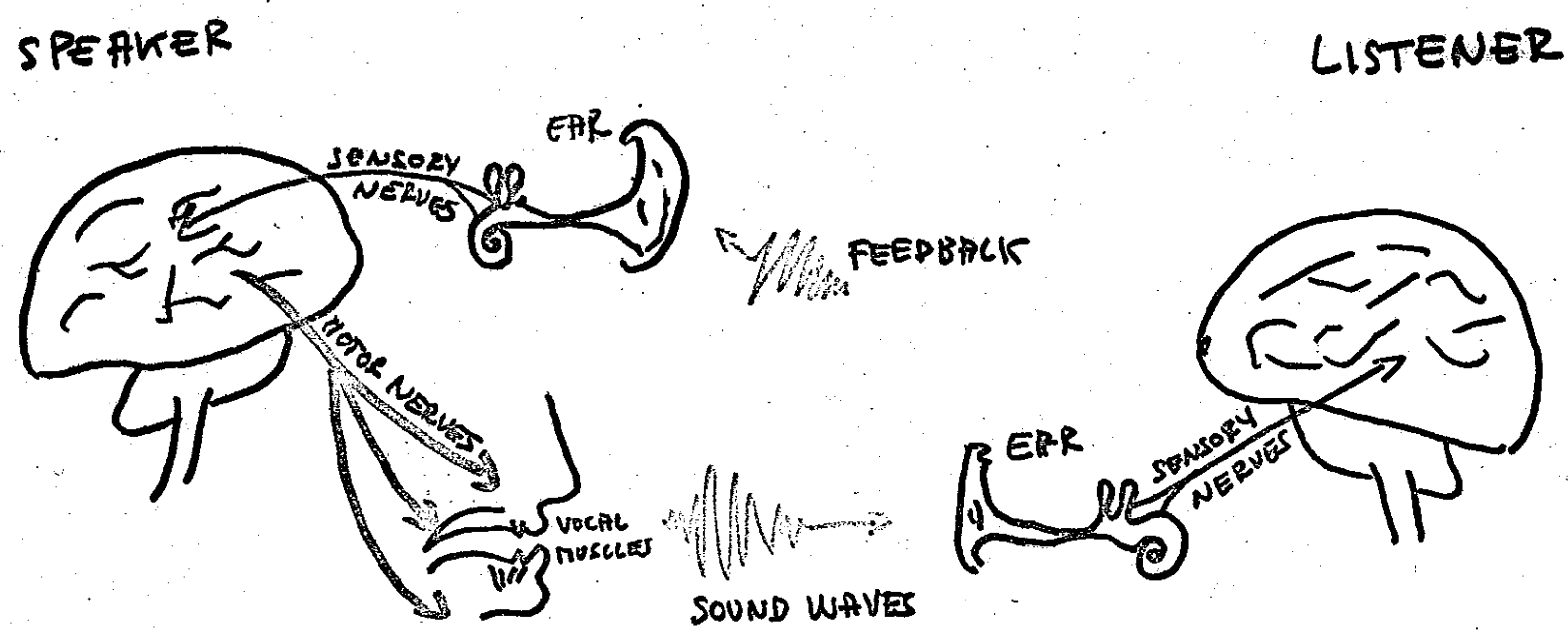
I don't think that biology will provide all the answers we need to understand this behavioral function which is unique to man. I believe, however, that we will get closer to the answers if language specialists in different disciplines come together and contribute in a cooperative manner to expand the understanding of a common field of interest. In other words, I suggest that we look at language from as many angles as possible.

Language learning distinguishes man from all other animals. Man has a highly complex capacity to develop meaningful patterns of expression with gestures and words. According to Lenneberg the capacity to acquire and employ human language does not depend upon the intelligence of the organism or the size of its brain, but upon the fact that it is a human organism. Why can only man learn to speak?[1] Presumably through evolution man developed a lateralization of the brain which assigned different functions to different hemispheres of the brain, language and most of skilled movement are normally located in the left hemisphere, perception of non-verbal patterns and spatial relations in the right. It is believed that this lateralization has made speech possible in man[2].

Language is the result of systems in the human brain working in an interdependent fashion. Figure 1 is a simple diagram of the speech chain. Concepts generating in the brain as a result of outside feedback are translated into words presumably in the cortical areas of language, transmitted by way of motor nerves and physiologically expressed by the peripheral language structures-vocal muscles- producing sounds (words). These sounds are than captured by the peripheral auditory structures of the listener and transmitted to his brain by way of sensory nerves.

In this paper I will be concerned with language activity in the brain level. The second part of this paper will try to show how language follows five biological premises empirically verifiable through observation and years of biological experimentation. In other words, that part of the paper will deal with language as a biological function.

THE SPEECH CHAIN



LINGUISTIC LEVEL central nervous system	→	PHYSIOLOGICAL LEVEL peripheral structures	→	ACOUSTIC LEVEL	→	PHYSIOLOGICAL LEVEL peripheral structures	→	LINGUISTIC LEVEL central nervous system

Figure 1. The speech chain: the different forms in which a spoken message exists in its progress from the mind of the speaker to the mind of the listener.

II

NEUROANATOMY AND NEUROPHYSIOLOGY OF THE LANGUAGE SYSTEM

Everyone knows that it takes a human brain to acquire a natural language such as English and this is true of language production as well as comprehension. What is it in the brain that makes language possible? In order to understand how the nervous system can carry out its complex task, it is necessary to know something about its anatomy and physiology. For purposes of description it is convenient to divide the nervous system into peripheral and central positions. The central nervous system consists of the brain and the spinal cord. The peripheral system consists largely of bundles of nerve fibers that link all portions of the body to the central nervous system. These bundles, containing thousands of individual axons are commonly called nerves. The fibers running in the peripheral nerves can be classified-according to function- as either sensory or motor.

The sensory fibers are concerned with the transmission of impulses initiated by an external stimulus; for example an acoustic stimulus reaching the ear is transformed, in the sensory receptors of the inner ear, into nerve impulses that are sent to the brain.

The motor fibers of peripheral nerves are responsible for getting nerve impulses to areas of the body where they cause muscular movements; for example motor fibers are responsible for movements of the lips.

The central nervous system is the mass of nerve cells or neurons and nerve fibers responsible for coordinating and directing a great deal of human activity. Messages from peripheral receptors are brought to the central system by sensory nerves. The central nervous system sorts them out and interprets these messages and initiates appropriate action; instructions are sent along motor nerves to the body's effector cells. Of course, activity can originate in the central nervous system-an intellectual activity, for example- without necessity of direct external stimulation. See Figure 2.

There is much experimental evidence that the central nervous system is organized along hierarchical lines: in passing from the spinal cord through the different levels of the brain, the structures become more and more complicated. We are here interested in the cerebral hemispheres, for not only do they control many of the lower functions but also memory, consciousness and voluntary activities. It is in the cerebral hemispheres that the central language system, which will be defined later, is located.

THE CORTEX

The great concentration of neurons in the folded surface layer of the brain are known as the cerebral cortex. These cells plus the neurons in some other structures of the central nervous system make up the brain's "gray matter". Most of the tracts of axons or nerve fibers that interconnect various portions of the brain are covered with a white isolating substance called the"white matter".[3]

As a result of experimental evidence such as electrical stimulation of certain parts of the cortex[4], it seems safe to say that certain localized areas of the cerebral cortex are essential for speech production and comprehension. Removal or damage to these areas result in partial or total loss of the ability to communicate verbally. Often other aspects of the intellect are also impaired, suggesting close interconnection between language and intellectual activities. From now on in this paper I will refer to the language production areas located in the cerebral cortex as Central Language System or CLS.

Since it is not possible to adequately depict in diagrams the brain and its components in any revealing way, a gross reference point will be given for the components of the CLS in a schematic way. The sheet of neurons forming the cortex can be separated into six layers composed of different types of neurons, folded over on itself. The smooth top parts of the folds are called gyri; the creases, sulci or fissures. No two brains are alike in the topographical configuration of gyri and sulci, although usually a number of "landmarks" can be identified: the Fissure of Rolando which separates the primary motor cortex (anterior) from the primary sensory cortex (posterior); the Fissure of Sylvius which marks the dorsal (top) edge of the temporal lobe; the major gyri (convolutions) of the frontal and temporal lobes-superior, middle and inferior, proceeding from top to bottom. A simplified sketch of the surface of the left hemisphere, showing the classical names for those parts of the cortex traditionally associated with language and speech is shown in Figure 3. If a cut is made vertically through Wernicke's area and the brain is viewed "head on" (a coronal section), the resulting view in shown in Figure 4- the area of importance in this view is Heschl"s Gyrus.

Since the gross topography alone is unsatisfactory as an anatomical basis of the neurolinguistic model, a sketch of the major cellular

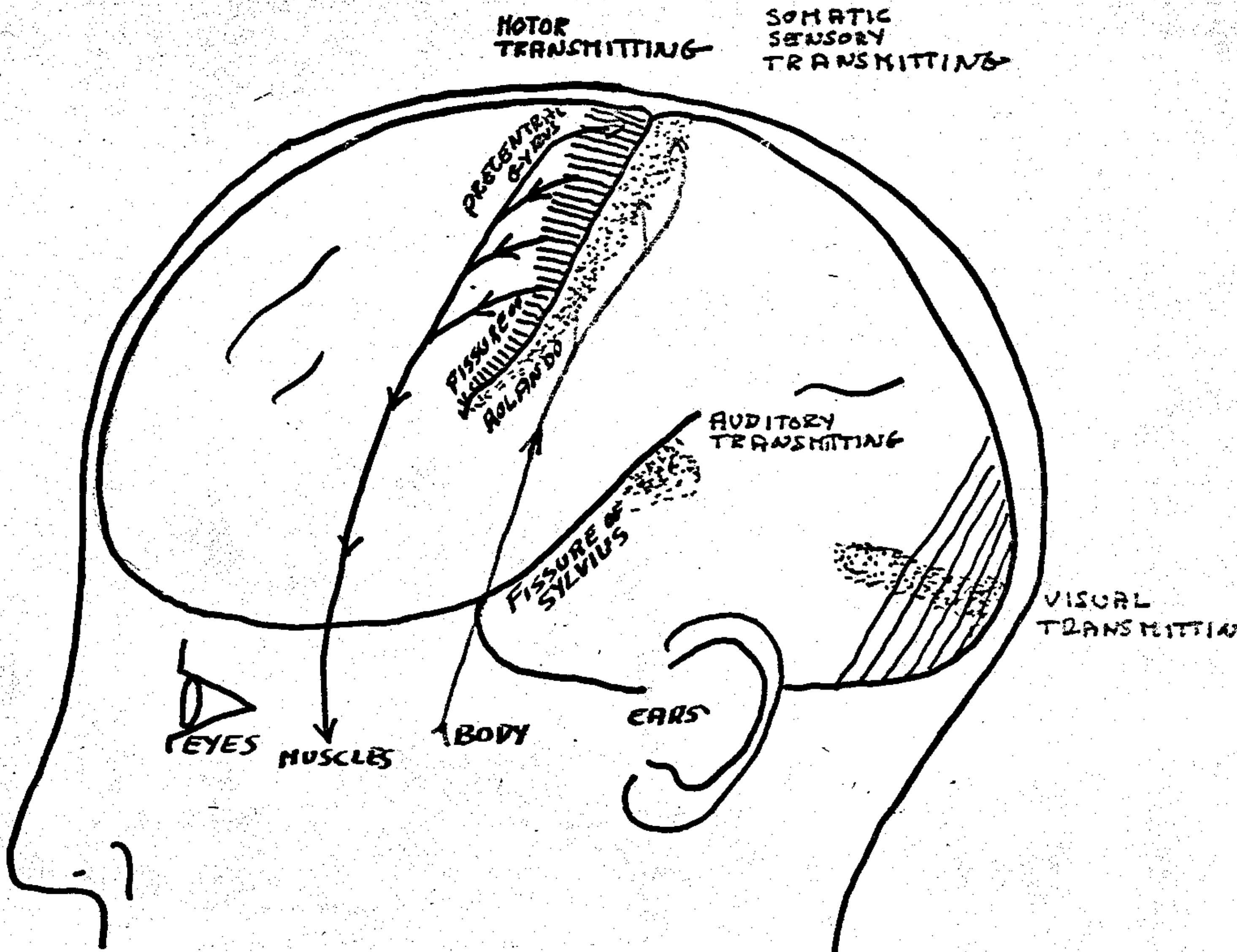


Figure 2 :

Projection areas of cortex
From:Penfield and Roberts. 1966.

Transmitting areas on the lines of communication with environment. Three important sensory transmitting areas (blue)pass afferent informative streams of impulses through the cerebral cortex to brain stem. The voluntary motor system carries impulses in a planned pattern through the motor transmitting area (red) on the precentral gyrus, out to the muscles that control voluntary movement. The functional contribution of the cortex to the sensory and motor streams that pass through is not clear.

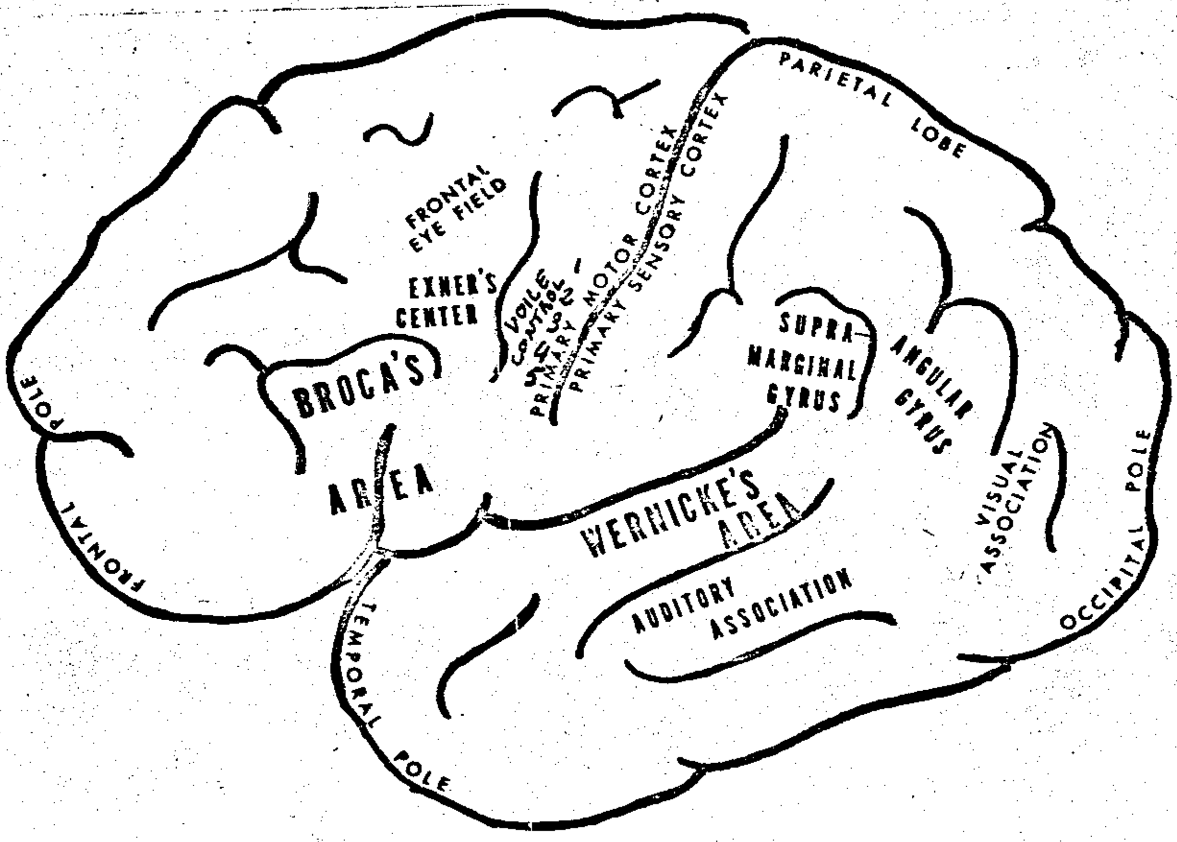


Figure 3: Left Hemisphere Language Areas

From: Whitaker (1971)

Voice Control:
1. vocalization
2. lips
3. jaw
4. tongue
5. throat

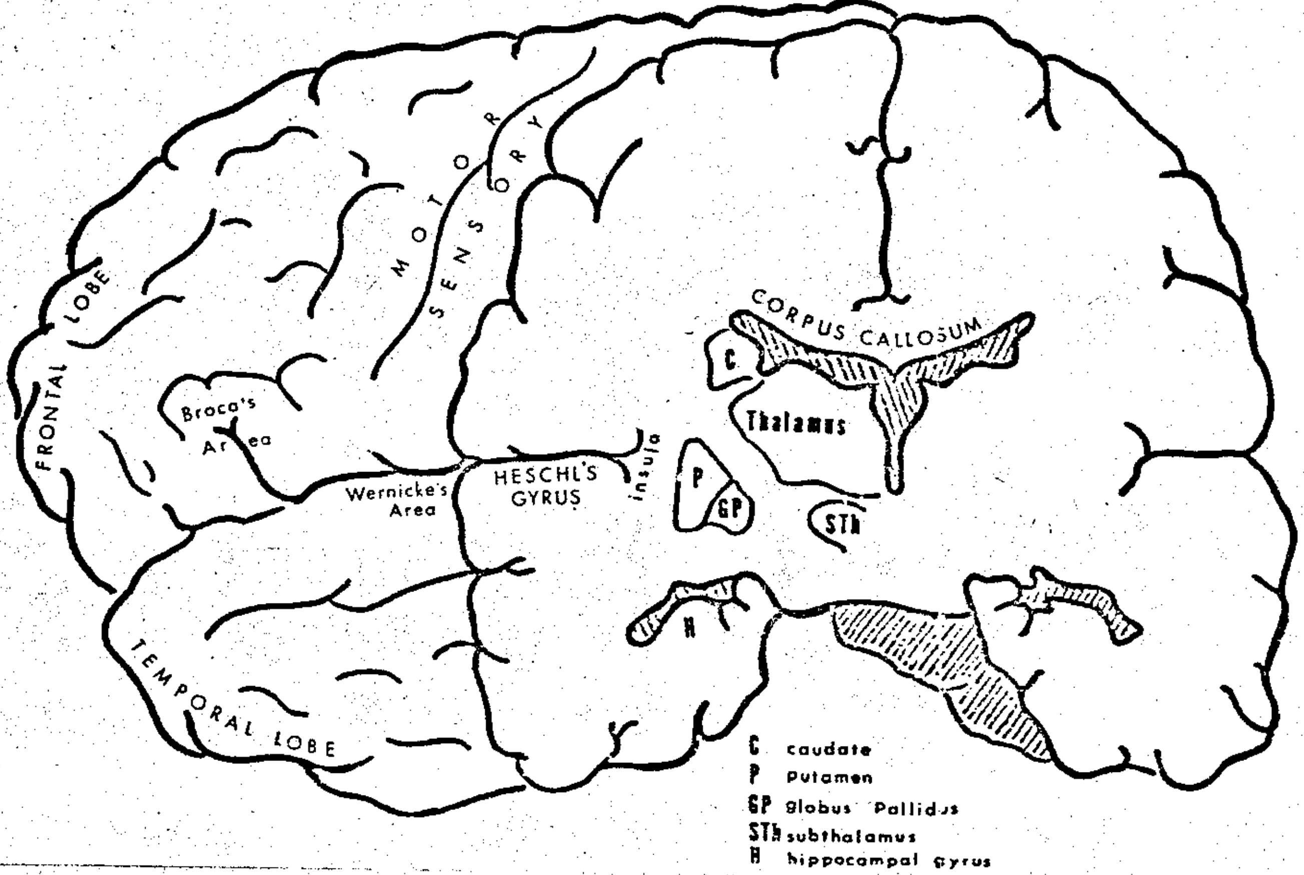


Figure 4. Coronal Section Through Heschl's Gyrus

From: Whitaker (1971).

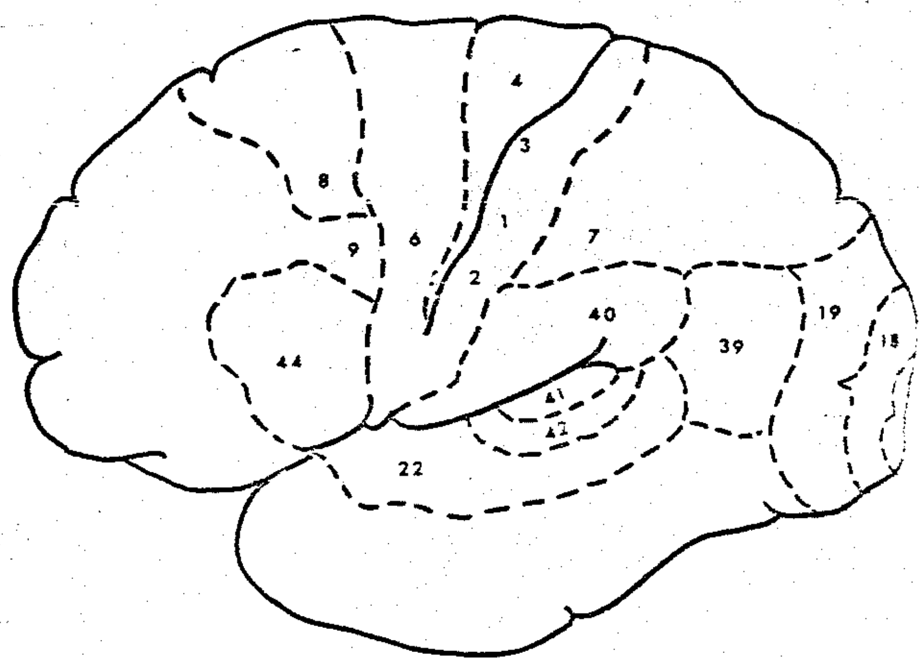


Figure 5: Cytoarchitectural Divisions of Left Hemisphere Language Areas (Brodman)

From: Whitaker (1971).

Areas 1,2 and 3 correlate with the sensory cortical area
Area 4 correlates with the primary motor area
Area 6 correlates with Exner's Center
Area 7 correlates with part of the Supramarginal Gyrus
Area 8 correlates with the frontal eye field
Areas 18 and 19 correlate with the Visual Association Cortex
Area 22 correlates with the Auditory Association cortex
Area 39 correlates with the Angular Gyrus
Area 41 correlates with Heschl's Gyrus
Areas 40 and 42 correlate with the Supramarginal Gyrus
Areas 42 and22 correlate with Wernicke's Area
Area 44 correlates with Broca's Area

differences is shown in Figure 5; these are based upon the original drawings of Brodmann and employ his numbering system. The major portions of the temporal and parietal lobes, in particular Wernicke's area, the Supramarginal Gyrus, the Angular Gyrus and the Auditory Association Area, is comprised of nerve cells arranged in six layers; this type of gray matter is called neurocortex; I will not describe it here.

It is interesting to notice the remarkable degree to which distinct cellular arrays in the cortex (the Brodman areas) correspond to the areas classically associated with the language system, a correlation that is easily seen by comparing Figures 3 and 5. Thus area 44 is correlated with Broca's Area, the foot of the inferior frontal gyrus. A portion of Area 6 is correlated with Exner's Center, the foot of the middle frontal gyrus. The primary motor and sensory cortical areas, anterior to and posterior to the Fissure of Rolando respectively, correlate with areas 4 and 2 respectively -note that the vocal tract areas are shown on the diagram, to indicate that the muscles of the neck and head are represented in these cortical fields. The Supramarginal Gyrus correlates with parts of Areas 40 and 22, the Angular Gyrus, with Area 39. Wernicke's Area correlates with Area 42 and probably parts of Area 22, and the Auditory Association field with the main part of Area 22. Heschl's Gyrus, shown in Figure 6, correlates with Area 41 of Brodman. Since the architectonic fields just described are essentially the same for all brains and the topography is not, it is reasonable to suggest that these fields are more appropriately considered the anatomical correlates of the language system. In order to simplify the discussion, however we will use the more familiar classical terms throughout this proposal.

It is well known that fields in the cortex interconnect with each other by way of cortico-cortical fibers as well as with sub-cortical and peripheral structures. It is postulated that the following regions of the cortex subserve the semantic/syntactic component and the lexicon of the grammar[5]: part of Wernicke's Area, the Auditory Association cortex, the Supramarginal Gyrus and part of the Angular Gyrus. It is highly unlikely that there are strict boundaries to this system in any one brain, even though we may presume that the general demarcation is definable. One suspects that there are individual differences in terms of how much of these cortical fields are actually recruited for the CLS just as there are individual differences in everything else. Lesions in these areas produce a range of defects that typically involve the following linguistic concepts: selection of appropriate grammatical categories, the syntactic integrity of the sentence as well as its major constituents, the noun phrase and the verb phrase, the selection of specific items within a semantic field, the ability to relate sentences of the same meaning with each other using syntactic transformations, the ability to make use of a normal vocabulary range, and the ability to string together meaningful sequence of words. The full linguistic details of these deficits are remarkable confirmation for many of our notions of grammatical organization.[6] Each of the postulated areas of the CLS are connected to each other <u>via</u> the short cortico-cortical fibers found in the gray matter, within the cortical mantle. These fibers, incidentally, rarely are found ouside the gray area; the connecting fibers found in the white matter beneath the cortex are generally longer, transhemispheric or inter-hemispheric connections. It is the latter fibers that connect each of these Areas of the CLS with the peripheral language production structures. Considering both types of connecting

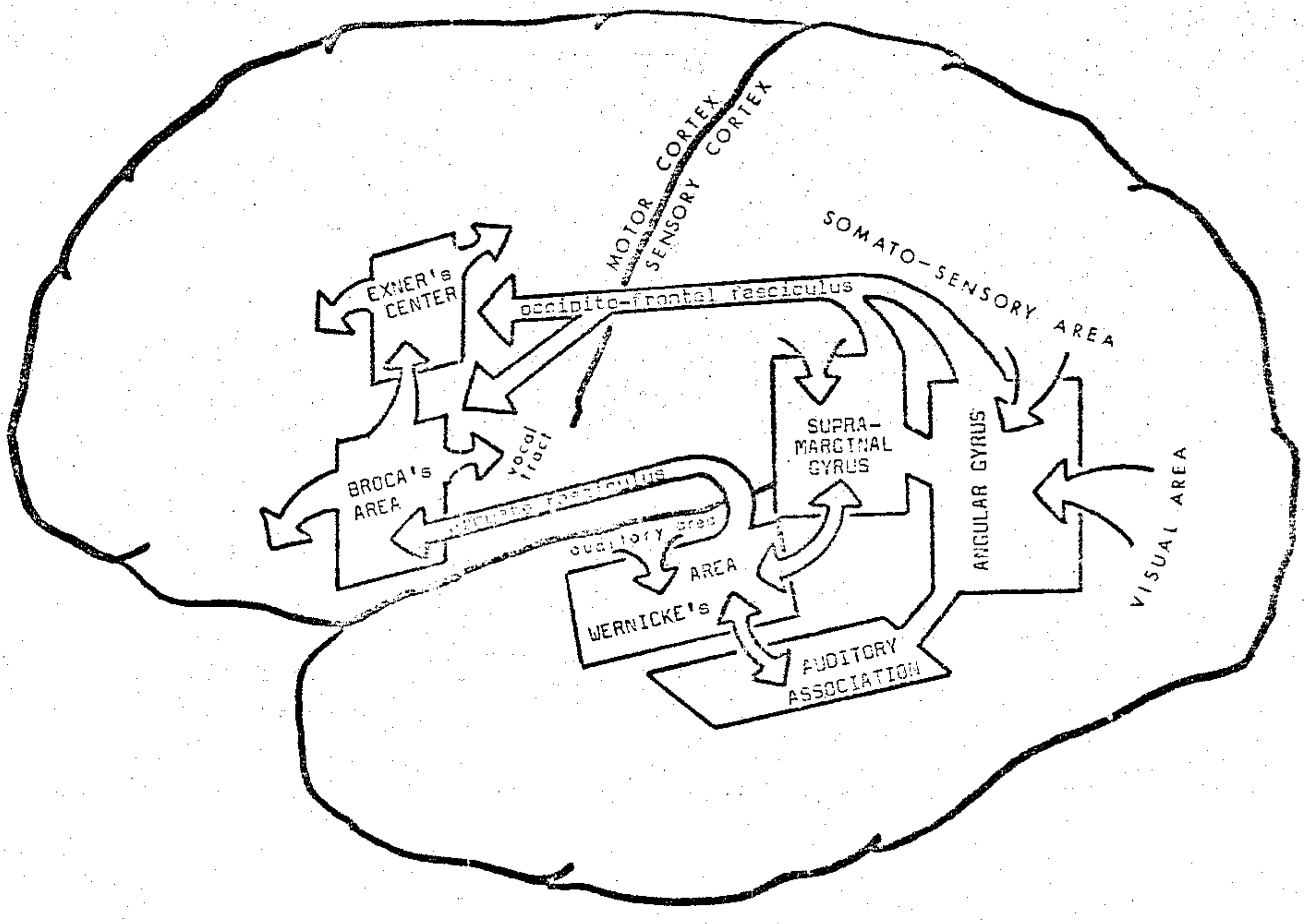


Figure 6: Anatomical Schematic of the CLS.

From: Whitaker (1971).

Cortico-cortical neuronal connections.

hemispheric connections. It is the latter fibers that connect some of these areas of the CLS with the peripheral language production structures. Considering both types of connecting fibers, we may conclude that the following pathways for the transfer of signals in the CLS exist: the Angular Gyrus connects with visual association cortex, Brodman Area 19; the Supramarginal Gyrus connects with general somatic afferent association cortex in Areas 40 and 7; the posterior portion of Wernicke's Area and the Auditory Association cortex connect with the association cortex (Area 42) surrounding Heschl's Gyrus, and portions of Wernicke's Area, Auditory Association Cortex and Angular Gyrus, connect via the long in intercortical fibers known as the Arcuate Fasciculus with Broca's Area and Exner's Center.Thus the anatomical connections provide the CLS with the requisite sources of information that a logical schematic requires.

There is presently little evidence for a cortical locus of the lexicon; oddly enough, there is even less evidence that lexical disruptions occur from lesions in non-central language system structures. The probable view based on current evidence is that the lexicon is a property of all nervous system structures that are associated with the language system. This suggests that certain aspects of language, particularly those which are stored or are part of a linguistic memory, may be biochemical in nature rather than either structural (areas or networks of neurons) or electrical (trains of neuronal impulses). One might thus be inclined to accept the hypothesis that memory storage in the brain is "holographic". One expects a reduction in the clarity and detail of a hologram if parts of the photo plate are destroyed, but

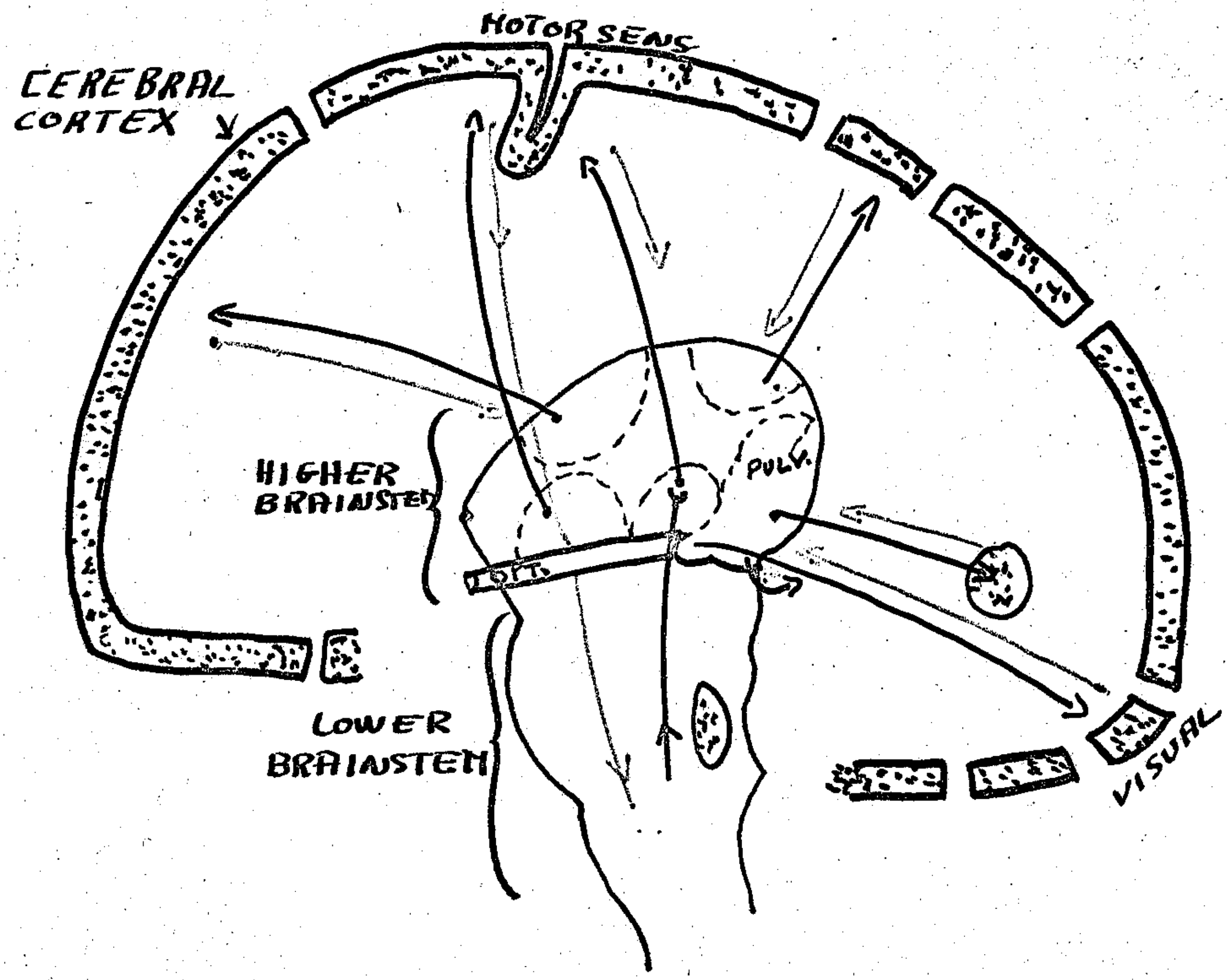


Figure 7 Diagram of connections between brain stem and cerebral cortex

After Penfield and Jasper (1954)

no "holes" or missing portions of the picture. Analogously, destruction of cortical language structures does not destroy the lexicon per se, but only quantitatively reduces it- this is a concomitant of aphasias associated with lesions to the CLS structures. Thus we may conclude that the lexicon is indeed a component of the CLS but represented within the anatomical structures of the CLS not as a separate system.

THE CENTRENCEPHALIC SYSTEM

We have so far presented some cortical aspects of the CLS. But what is actually coordinating and integrating the activities of the cortex? Back in 1959 Penfield said:

> It is obvious that the brain must have a central coordinating and integrating mechanism. If this "machine" is at all like other machines, there must be a place toward which streams of sensory impulses converge. There must be a place from which streams of motor impulses emerge to move the two hands in a simultaneous planned action. There must be neuronal circuits in which activity of both hemispheres is somehow summarized and fused-circuits of activation which make conscious planning possible.
>
> From certain physiological points of view the foregoing assumption might be denied at once. Since no one knows the nature of mental activity, it is easy to conceive it in relation to the surface of the two hemispheres in simultaneous neuronal action (and even in the peripheral nerves too) as it is to believe that it depends on a centrally placed zone of neuron circuits where neuronal activity is finally integrated
>
> But a neurophysiologist may not listen to such objections especially when the evidence before him seems to indicate that such central integrating activity is actually taking place. And a clinician, who is forced to take action in order to deal with patients must construct a working hypothesis.
>
> There is evidence of a level of integration within the central nervous system that is higher than that to be

> found in the cerebral cortex. There is a regional localization of the neuronal mechanism involved in this integration which is most intimately associated with the initiation of voluntary activity and with the sensory summation prerequisite to it. All regions of the brain may well be involved in normal conscious processes, but the indispensable substratum of consciousness lies outside the cerebral cortex,...not in the new brain but in the old...probably in the diencephalon.7

Penfield had quite weak supporting evidence. It now appears that to a certain degree he was correct in his hypothesis. The thalamus is located approximately in the center of the brain, in the area which Penfield called the diencephalon. It is possible, using electrostimulation techniques to cause aphasic language disruptions in the left pulvinar and perhaps in some other left-side thalamic nuclei (the thalamus is composed of a number of nuclei). The fact that the right pulvinar does not yield such data is rather dramatic corroboration of the role of these thalamic nuclei in the CLS, since the lateralization of cortical language functions has been well established. On the aphasic evidence alone it seems necessary to include the pulvinar nucleus in the CLS mechanisms. Neuronal connections between the brain stem or centrencephalic system and the cortex would hypothetically transmit impulses from one part of the brain to the other. Figure 7 grossly shows some of the pathways. Figures 8 and 9 show the fibers which make up the cortico-thalamic and the thalamo-cortical tracts, as well as connections between the posterior speech area of the cortex to the pulvinar nucleus of the thalamus.

At the present time we still don't know to what extent the centrencephalic system controls the activities in the cortex. Surely the limbic system, partially responsible for what we call

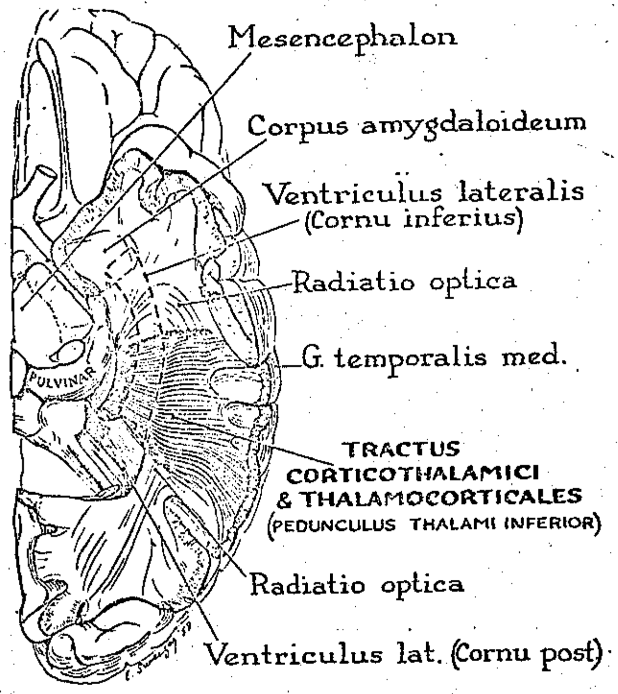


Figure 8: Drawing of left hemisphere seen fron below to show the nerve fiber projection connections between the posterior speech area on the left middle temporal convolution and the pulvinar. The fibers which make up the cortico-thalamic and the thalamo-cortical tracts are drawn and labelled. From: Penfield and Roberts (1959).

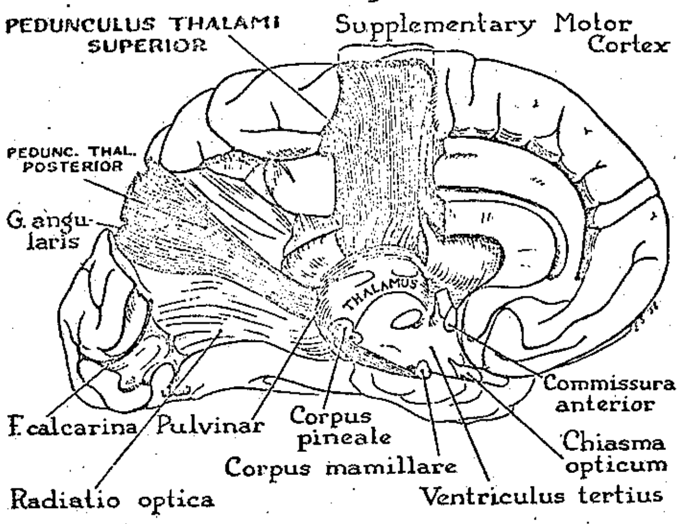


Figure 9: Drawing of the left hemisphere seen from the mesial surface to show connections between the posterior speech area of cortex to pulvinar and similar connections between superior speech area and thalamus. From: Penfield and Roberts (1959).

emotion must send feedback to the thalamus and other areas of the brain stem. But who has the final word? Is it the centrencephalic system? In my opinion it cannot work alone. Hypothetically I would say that it functions as coordinator and integrator of the activities produced in other parts of the system.

III

TOWARD AN UNDERSTANDING OF THE BIOLOGICAL BASES OF LANGUAGE

We have looked at some neurological aspects of language. Now I will discuss how language, as a cognitive function, follows some general biological premises generally accepted to apply to other biological forms of behavior. First let's define a cognitive function as the behavioral manifestation of physiological processes. Language is, in biological terms, the behavioral manifestation of physiological processes in the CLS and peripheral language structures.

Premise 1: A cognitive function is species-specific. A cognitive function is a cerebral function that mediates between sensory input and motor output, i. e., capacity for problem solving, facility for memorizing certain things, etc.

Language is species-specific. Language depends upon cognition. Certain specializations in peripheral anatomy and physiology account for some of the universal features of natural languages. Total mastery of a language by an individual may be accomplished despite severe anomalies (peripheral), indicating that cerebral function is the determining factor for language bahavior as we know it in contemporary man. Therefore language is the consequence of the biological peculiarities that make a human-type cognition possible.. The existence of our cognitive processes entails a potential for language, a capacity for a communication system that must necessarily be of one specific type: human.

Premise 2: Specific features of cognitive function are replicated in every member of the species, although there are individual differences among all creatures, there is close resemblance between members of the same species.

The capacity for learning a first language is inherited by every member of the human species. A child whether he is English or Chinese will learn to speak his mother tongue. The learning stages may be different due to individual differences and differences in the languages, but in the end they will both speak a natural language.

Premise 3: Cognitive function differentiates with maturation. Form and function are not imposed upon the developing creature from the outside, but gradually develop through a process of differentiation. The development plan is based on information contained in the developing tissues although some functions need an outside stimulus for the initiation of the operation.

The capacity for learning a language develops genetically in the course of physical maturation: a child doesn't begin to speak at birth, despite his mother talking to him, and the presence of adults and children speaking around him. I believe that at birth a child is not biologically ready to learn a language, just as a bird is not ready to fly when it hatches. However, certain environmental conditions must also be present to make it possible for language to develop[8]. The child must go through a process of biological differentiation before he can begin to learn a language.

Premise 4: At birth man is relatively immature, certain aspects of his behavior and cognitive functions emerge only during infancy or later. Other primates are much more advanced than man at birth. Going down in theevolutionary scale, most lower vertebrates and invertebrates are fully equiped for self sufficiency at birth. Biologically speaking, however, these organisms are much simpler. Higher complexity seems to call for longer maturation processes.

Maturation brings cognitive processes to a state that we might call language-readiness. Raw material is now needed by the organism to shape its own language development (somewhat the same process as in nourishment and growth. The raw material for the individual ready to learn a language is the language spoken by adults around him. In Lenneberg's words:

> ...the course of language unfolding is quite strictly prescribed through a unique maturational path traversed by cognition and thus we may say that language-readiness is a state of latent language structure . The unfolding of language is a process of actualization in which latent language is transformed into realized structure. The actualization of latent structure to realized structure is to give the underlying cognitive type a concrete form.9

If language is an aspect of a fundamental biologically determined process it might be fruitful to think of maturation including growth and the development of behavior such as language as the succession of desequilibria followed by rearrangements bringing further desequilibria, which in turn produce further rearrangements until maturity is reached. Language readiness is a state of desequilibrium during which the mind creates a place for the language components to fit in.

This desequilibrium state is of limited duration; it begins at around age two and declines with cerebral maturation in the early teens. At that age the cognitive processes are stabilized, cerebral reorganization of functions is no longer possible.[10]

Lenneberg states:

> ...the language potential and the latent structure may be assumed to be replicated in every healthy human being; because they are a consequence of human-specific cognitive processes and a human-specific course of maturation. In other words universal grammar is of a unique type, common to all men, and it is entirely the by-product of peculiar modes of cognition based upon the biological constitution of the individual. This notion of replication...also leads to assure that the actualization process from latent to realized structure is universal because of replicated sequences of similar states of desequilibrium...
>
> Because latent structure is replicated in every child, and because all languages must have an inner form of identical type (though an infinite number of variations is possible), every child may learn any language with equal ease...Insintence upon universal underlying identity of type in all languages may be difficult to understand in the case of differences in rules of syntax and semantic divergences. This puzzle is solved by considering the remarkable freedom allowed individual speakers to make creative and novel use of word-meanings, to reclassify words into various syntactic categories, and to take creative freedoms with rules of syntax. 11

Hebb, Lambert and Tucker[12] disagree with Lenneberg's latent language proposal on the grounds that it overlooks the great similarity in the early environments of children everywhere. However, Lenneberg does not say that learning does not occur. In my opinion heredity is just as important as learning in the language process. I think that Lenneberg is merely stressing that heredity <u>is</u> present.

Premise 5: Some social phenomena among animals come about by adaptation of the behavior of the growing individual to the behavior of other individuals around him. Man and many animals require specific social conditions for adequate development. In animals the proper stimulation must occur during a narrow formative period in infancy; failing this, development might be distorted[8]. When the individual becomes maturationally ready, he doesn't perform unless properly stimulated.

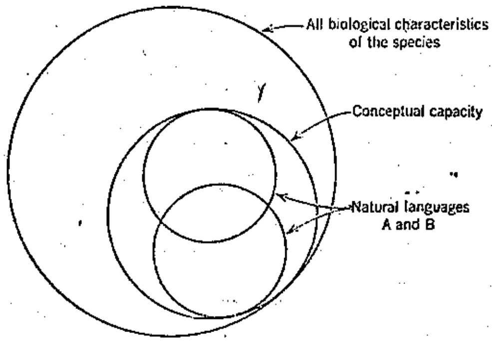
The raw material (adult language from which the child synthesizes steps for his own language development) cannot be the cause of the developing structures as presented by the original beginnings in the infant's language acquisition. Primitive stages of language in the child are too different from adult language to be regarded as a mere imitation of the input. There is no evidence that the adults surrounding the child are the causative agents that determine language onset or its course of development. However, social stimulation is probably required as a trigger that sets off the reaction. A good image is perhaps Lenneberg's concept of resonance:

> In a given state of maturation, exposure to adult language behavior has an excitatory effect upon the actualization process much the way a certain frequency may have an excitatory effect upon a specific resonator: the object begins to vibrate in the presence of the sound. In the case of language onset the energy required for the resonance is, in a sense supplied by the individual himself; if the trigger analogy is preferred we might say that he "unwinds" himself... The resonance analogy is comparable to the child's hearing of French, resulting in his speaking French, each natural language being a selected frequency band from the limited possible frequency range that is capable of eliciting resonance.[13]

The continuation of language behavior in our species is not analogous to cultural tradition which is handed down as information from generation to generation. The individual is not a passive vehicle through which information is transmitted. He is an autonomous unit, constructed similarly to the other human beings around him, ready to behave in a similar way. His behavior is activated by social contact but he can only function if he can recreate the entire language mechanism out of the raw material presented to him. This recreation is learning. The individual must be able to synthesize the language mechanism from the adult language which surrounds him the same way as he must be able to synthesize protein from the food he eats. This language as well as this protein is species-specific and is similar to the one synthesized by other members of the human species.

Looking into the very speculative field of evolution, and accepting a Darwinian point of view for selection, how much has language contributed to natural selection? Language <u>per se</u> can be a factor for natural selection. This can be observed today in areas of the globe where, due to geographical isolation and the absence of means of communication a language has developed within a population without affecting the neighboring ones, thus causing a certain amount of inbreeding within the population with little chance of renewing the gene pool; a good example of this is the Basque Country. Furthermore most people marry within their language group. In relationships between people with different mother tongues, one of the two people at least is able to express himself in the other person's language. Thus, language can be a factor responsible for inbreeding within a population thus affecting biology or itself being considered a biological factor.

Man has a capacity for conceptualization which no other species has. Different languages differ in the particular conceptualization processes that are reflected in their vocabulary. Thus, the process of concept formation must be regulated by biological determinants. For this reason different languages may have conceptualization areas in common. But does the bilingual individual use more of his conceptualization potential? It would appear to be so, but so far we only have an intuitive base to hypothesize. The diagram below shows the relationship of natural languages to the human capacity for conceptualization. It is a proposal which might one day prove to be true.



From: Lenneberg (1967) Figure 10.

There are many reasons to believe that the processes the realized outer structure of a natural language comes about are deeply-rooted species-specific innate properties of man's biological nature. This does not mean that learning does not take place. I believe that in every cognitive function learning is involved, given the proper biological prerequisites. As this stage of the game I tend to take a "middle of the road position": for learning to occur in the language process a human brain and human peripheral structures are needed. How much of the learning is biological and how much is psychological? So far we have no definite answers, but in my opinion there are no strict boundaries between what we call biology and what we call psychology. Closer cooperation between scientists in both fields might lead to less biased conclusions.

ADDENDUM

Most experts will agree that language is a higher human function (as opposed to the lower, better understood functions such as respiration, excretion, etc.) Moreover it has not yet been shown that any other species can actually use language the way ours can, that is with an ability to conceptualize and verbalize concepts. As a higher function, language should be studied taking into consideration the other higher functions of the human brain, which actually constitute what we call the mind. These are memory, attention, perception, cognition and intelligence, all of which necessitate of one another to produce the extraordinarily complicated phenomenon we call human behavior. It is empirically clear that one cannot learn language if one is unable to retain and store information, to pay enough attention for the information to 'get in' in the first place, to perceive auditory or visual stimuli, and to integrate the perceived information into a 'meaningful' form. It is difficult then to say where language stops and memory comes in, where memory stops and attention comes in, where attention stops and perception comes is and so on.

We are dealing here with a system which is in my opinion far greater than the sum of its parts. I chose to deal with the biology of this system. At the moment we can only expect to build a very speculative model of this system and we are unable to explain it in a purely biological framework. Language is a part of this system, but not an independent one. We can hope to elucidate its nature only by studying it in the context of the other higher human functions.

FOOTNOTES

1. Washoe learned sign language only after careful planning and extensive training by the human experimenters. I don't consider Washoe's language comparable to human language.(Washoe is a chimpanzee).

2. Lenneberg discusses the subject of lateralization quite extensively in p. 66 of his book. (see bibliography, Lenneberg, 1967). For a good discussion on lateralization see Right and Left Thinking. by R. Ornstein in Psychology Today, May 1973, vol.6, no.12

3. Some interesting properties of the cortical areas are worth mentioning: the myelin sheath surrounding an axon presumably acts as an insulator that permits neuronal impulses to travel at a much faster rate. Dendritic growth is completed later in this area than in other areas of the brain. (The dendrite component of a neuron can be regarded as its information source: the more complex a dendritic structure the more sources of excitatory and inhibitory impulses available to influence the firing of the cell body).

4. Electrical stimulation of exposed cortex during surgery and cases of aphasia and other pathologies of the language system are discussed extensively in Lenneberg (1967), Whitaker (1971) and Penfield and Roberts (1959), and will not be discussed here.

5. see footnote 4.

6. Some details of these deficits may be found in Chapter 4 of Whitaker (1971).

7. Penfield and Roberts (1959). p. 20-21.

8. For more information and detailed studies see Lenneberg (1967), Chapter 7.

9. Lenneberg, (1967) p. 375.

10. For more information see Chapter 7, Lenneberg(1967).

11. Lenneberg,(1967), p.375.

12. Hebb, D. O., Lambert, W.E., and Tucker, R. A DMZ in the Language War. in Psychology Today, April 1973, vol 6. no.11.

13. Lenneberg, (1967), p. 378.

14. I am talking here of the desequillibrium caused by critical periods the organism goes through. An example of critical period would be the age at which a baby is biologically ready for language learning.

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