A BRIEF DISCUSSION ON THE BIOLOGICAL FACTORS IN THE ACQUISITION OF LANGUAGE

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■**ABSTRACT**: The understanding of how language is acquired and the role the brain plays in the language acquisition process are crucial because the development of language is one of the most important factors in human development. The analysis of language development is intrinsically connected with one's awareness of how human beings or human brains perceive, learn, control, and coordinate elaborate behaviour. The study of language development, therefore, involves research on motor, perceptual, and cognitive development. This paper reviews the three major theories of language acquisition, namely, behaviouristic, psycholinguistic, and interactionistic and examines the biological component of language acquisition and the brain's role in the language development process.

■**KEY WORDS**: Language Acquisition. SLA. Critical Period Hypothesis. Brain Damage.

Introduction

The development of language is generally considered to be determined by factors in both the environment and a person's neurobiological make-up. Theories of language acquisition fall within three major schools of thought, namely, the behavioristic, the psycholinguistic (also referred to as nativistic or mentalistic), and the interactionistic (also referred to as cognitive) perspectives. This paper defines each of these perspectives and examines the biological component of language, accepted by the

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psycholinguistic and interactionistic proponents alike. In examining the biological component of language, this paper also discusses the critical period for language acquisition, theories of language development from the biological perspective, as well as information from studies of individuals with neurological or biological dysfunction. The study of the language development of persons with specific types of brain damage or other biological disturbances has provided much information regarding the brain's role in the language process. Finally, this paper discusses how these innate, biological factors, influence the acquisition of language.

The three perspectives of language acquisition

The first perspective of language acquisition to be discussed in this paper is the behaviouristic position (SKINNER, 1987), which builds on learning principles to explain language acquisition. Behaviourists believe that the learner begins with no knowledge of language but possesses the competence to learn it. Specifically, they contend that one learns through the reinforcement of imitation. For instance, infants repeat words or babbles after their parents without having a clear knowledge of the meaning of those words. This reinforcement of babbling and the shaping of vocal behaviour account for the very first stage of learning. The child's babbling will later turn into words that will subsequently be associated with meanings and promote communication.

According to the behaviouristic perspective, language is acquired from factors in the environment. Behaviourists believe that the development of language is a function of stimulus, response, and reinforcement[2]. Behaviourists view the language learner as a language-producing machine. Language input is made available to the learner in the form of stimuli/feedback. In the behaviouristic model, the learner is passive, and the environment is the determining factor.

Another perspective of language learning is the psycholinguistic position. The proponents of this approach argue that the learner is the grand initiator of all language learning. The learner possesses an innate capacity for dealing with language and activates a theory or process of grammar (grammatical theory) to help understand and produce an innumerable number of phrases or sentences. Language input is, therefore, of little consequence other than being only a trigger of the innate mental processes to begin language formation. Psycholinguists claim that none of the learner's output can be explained in terms of the characteristics of the input. Instead, the learner is biologically predisposed to learn languages as the brain develops, and the environment simply triggers its emergence. Noam Chomsky (1965, 1980, 2005)[3], the

[2] See for example the study developed by Moerk (1983).

[3] See also Ellis (1985).

most famous of the psycholinguists, called this innate or biological component the Language Acquisition Device (LAD).

A third perspective is that of the interactionists. Proponents of the interactionistic perspective claim that the development of language is the result of interaction between the learner's mental abilities and the linguistic environment (see for example CHAPMAN, 2000; HUITT; HUMMEL, 2003; PIAGET, 1954, 1999). The learner acquires language through the interaction of perceptual-cognitive capacities and experiences. The learner's environment and neurological maturation determine learning. Therefore, language and thought are simultaneously developed as the learner passes through a series of fixed developmental stages requiring more and more complex strategies of cognitive organization.

Interactionists consider the capacity for learning language to be innate. Interactionists claim that the learner must internalize linguistic structures from the environment and must become aware of the social function of communication. Thus, the important data are not only the utterances produced by the learner, but the discourse which learner and caretaker (e.g., father and/or mother) jointly construct. Piaget (1954, 1999; PIAGET; INHELDER, 1969), the major proponent of the interactionistic position, believed that the child's environment and neurological maturation determine learning. As a result, language development programs based on the interactionistic perspective are based on two ideas: "(a) meaning is brought to a child's language through interaction with the environment, and (b) the child uses speech to control the environment" (MERCER, 1997, p.418).

In summary, the above discussion shows that these three perspectives overlap and complement each other. While behaviourists claim that learning is the result of input from the linguistic environment, psycholinguists believe that language input works only as a trigger of the innate mental processes that is responsible for language formation. This means that the linguistic environment contributes little to language learning. Interactionists, on the other hand, combine the behaviouristic and the psycholinguistic perspectives, as they believe that the interaction between the learner's mental abilities and the linguistic environment promotes the development of language.

Innate human language component

Lenneberg (1964) set forth the seminal arguments for the innate human component, by presenting four arguments for biological innateness of psychological

capacities. These are (1) universal appearance of a trait at a single time across a species; (2) universal appearance across time for a group; (3) no learning of the trait is possible; (4) individual development of a trait rigidly follows a given schedule regardless of the particular experience of the organism. These were constructed in parallel to arguments in biology for the innateness of physical traits. Lenneberg's (1964) arguments were later studied by Chomsky (1965, 1980, 2005) and popularised by Pinker (1994).

Further, Cairns (1996) argues that there is a large innate component to human language. She argues that while human language is biologically based, a child who never heard human language would not simply acquire speech based on the innate component alone. There is an indisputable environmental component as well. Cairns (1996) goes on to say that studies have been conducted on children who are deaf and reared in homes of hearing parents without exposure to formal sign language systems. These studies have shown that the children do develop crude systems of manual communication. However, their systems are never so complex as to be considered full human language.

Cairns (1996) argues that while there is a brain-based component to human language, it is probably safer to take a psycholinguistic approach to language development. This approach would view the infant as especially prepared neurologically to organize speech that is heard into a human language system. The psycholinguistic approach claims that children acquire more language than would be predicted because of the speech they hear. They will produce phrases or sentences that nobody has said before. It proves that the children not only repeat what they hear but also combine the different words and linguistic constructions they hear to articulate original utterances. This approach is controversial and Cairns (1996, p.14) states that "[...] it is similar to the nature-nurture debate that has taken place in many areas of human psychology."

Critical period for language acquisition

A further point made by Cairns (1996), which accounts for the existence of the LAD contented by psycholinguists, is that there is a critical period for language acquisition, also called Critical Period Hypothesis (CPH) (LENNEBERG, 1967). This means that the first few years of life is the crucial time in which an individual can acquire a first language if presented with adequate stimuli. If language input does not occur during these first few years of life, the individual will never achieve a full command of language. Although this topic remains controversial and the subject of debate, particularly because the evidence

for such hypothesis is limited, and support comes largely from theoretical arguments and analogies to other critical periods in biology such as visual development, the CPH is widely accepted.

According to the CPH, a related factor to the process by which the language capability develops in human beings is the maturity of the brain. As the brain becomes more complex, the role that learning plays in the acquisition and refinement of social and communicative skills becomes increasingly significant. The relative maturation levels of the human brain at birth are significantly different from its maturation levels during later infancy. The more immature the brain, the greater its flexibility is in what can be learnt by a developing organism. Further, according to Studdert-Kennedy (1991), maturational factors also influence the sorts of information that can be learnt at different ages. As will be discussed below, although learning abilities may vary from individual to individual, maturational factors indeed seem to affect the rate of language development.

Curtiss et al. (1974) discuss rare and unfortunate cases where children did not acquire language before puberty. These sad cases involved children who were abandoned or imprisoned by abusive parents. One particular case involved a girl named Genie. She had been isolated and imprisoned by an abusive father until the age of 13. Linguists at the University of California, Los Angeles, attempted to teach her language with only slight success. Although she acquired a vocabulary and some rudimentary word order rules, she was never able to acquire the morphological and syntactic rules of English. This indicates that languages are learnt more easily before puberty.

Further support for the CPH comes from studies of second language acquisition (SLA). For instance, Seliger, Krashen, and Ladefoged (1975) found that second languages learnt before puberty are usually spoken without an accent. However, it should be noted that the CPH is much less widely accepted in the field of SLA. For instance, it is arguable that older learners may rarely achieve native-like fluency such as that displayed by younger learners; yet older learners may progress faster than children may in the initial stages of second language acquisition.

However, Singleton and Lengyel (1995)[4] stated that, in learning a second language, being younger is better in the long run, but he also pointed out that there are many exceptions. For example, he noted that five percent of adult bilinguals mastered a second language even though they began learning it when they were well into adulthood. Likewise, DeKeyser (2000)[5]; argued that although it is true that there is a CPH, this does not mean that adults cannot learn a second language perfectly, at least on the syntactic level. He discusses the role of language aptitude as

[4] See also Singleton (2005).

[5] See also DeKeyser e Larson-Hall (2005).

a determining factor in language acquisition as opposed to the CPH. See Krashen (1981) for further discussion on the CPH in relation to SLA.

The discussion in this paper has implications for educators and bilingual parents. For instance, in many countries, children begin learning a second language in their first years in school, while in others second language learning only takes place at the high school level. A further debatable point is the ideal age for bilingual parents to start speaking a second language with their children at home. These examples are consistent with the results of the studies mentioned above, and therefore highlight the importance of understanding how language is acquired and the role the brain plays in the language acquisition process.

The role of the brain

The theories on the role of the brain and how the brain processes and produces language focus on the connection between specific biological factors of the human body and language development. The field of neuroscience has studied how human beings use words or signs to produce sentences to transmit the concepts in the minds to others and how human beings comprehend words spoken by others and turn them into concepts in the mind (DAMASIO; DAMASIO, 1992). To a great extent, the findings and ideas of how the brain processes and produces language are based on theory rather than on a complete understanding of the specific, tangible, anatomical factors at work.

Damasio and Damasio (1992) theorize that three interacting sets of structures operate in the brain to process and produce language. Firstly, a large collection of neural systems in the right and left hemispheres processes non-language interactions between the body and its environment. These interactions are linked by sensory and motor systems processing anything that a person does, perceives, thinks, or feels while acting in the world. The brain not only categorizes non-language representations such as shape, colour, sequence, and emotional state, but also constructs another level of representation for the results of its classification. As a result of this collection of neural systems, human beings are capable of organizing objects, events, and relationships. The brain categorizes this input into successive layers of categories and symbolic representations that form the foundation for abstraction and metaphor.

Secondly, a smaller number of neurosystems in the left cerebral hemisphere represent phoneme combinations and syntactic rules for combining words. When stimulated from within the brain these systems build word-forms and produce either spoken or written sentences. When stimulated from the environment, these

neurosystems perform the initial processing of auditory or visual language signals from incoming sensory input.

Finally, Damasio and Damasio (1992) also believe that there is a third collection of structures located largely in the left hemisphere mediating between the first and the second neurosystem. This third set, enlarging on the work of the first two neurosystems, transforms concepts into word-forms and expressive language. It is also capable of receiving words and causing the brain to elicit the corresponding concepts. In other words, these structures link the concept and the production of words and sentences.

Much of the understanding of how the brain processes and produces language comes from studies of persons with specific types of brain damage or other structural brain disorders. There are no precise answers regarding what body systems contribute to normal language development, how these contributions occur, and how malfunctions influence language disorders; however, it is known that certain sensory and other physiological systems must be intact and developing normally for language acquisition to occur properly (HARDMAN; DREW; EGAN, 1996). For example, if a severe hearing impairment is present, a language deficit may result (LONIGAN et al., 1992). For instance, it has also been documented that children experiencing a lengthy history of otitis media (an infection or inflammation of the middle ear) may have expressive language delays (PAUL; LYNN; LOHR-FLANDERS, 1993). Many developmental disabilities can also directly affect the development of language. Howard et al. (1997, p.92) state that:

> Clefts of the lip and/or palate and oral-structure anomalies associated with Down syndrome influence phonological production. Cerebral palsy may result in reduced respiratory capacity that hampers speech production as well. Other developmental disabilities affect children's rate of learning and slow the acquisition of content and use. Autism, for example, is linked with aberrations in all areas of language development.

Environmental impoverishment during the years of infancy can have pronounced effects upon the social and cognitive functioning of children. Serious brain damage can affect and deter normal language development. Neurological damage that may affect language can occur prenatally, during birth, or at anytime throughout life (HUDSON; MURDOCH, 1992).

Virtually everything we know of how language functions are organized in the human brain has been learnt from abnormal conditions or under abnormal circumstances such as brain damage, brain surgery, electrical stimulation of brains

exposed during surgery, and the effects of drugs on the brain (GESCHWIND, 1972). Of these, the most important has been the study of language disorders making use of the findings of post-mortem analysis of the brain in patients who had suffered brain damage. These studies have resulted in the development of models of how the language areas of the brain are interconnected and what each area of the brain is responsible for.

Brain damage and language disturbances

Paul Pierre Broca, a French physician, pathologist, anatomist, anthropologist, and pioneer in neurosurgery, published the first of a series of papers on language and the brain in 1861 (BROCA, 1861a, 1861b; HOTHERSALL, 1995; SAGAN, 1979). Broca made two important contributions to the study of language and the brain. Broca was the first to point out that damage to a specific portion of the brain results in disturbances of language output. He also reported that damage to the left half of the brain led to disorders of spoken language but that destruction of corresponding areas in the right side of the brain left language abilities intact.

Broca's work was based on studies of people with aphemia, which was later renamed aphasia. He showed that patients who could not speak had a neurosyphilitic lesion in one side of the brain, exactly where speech is controlled. The portion he identified, lying in one of the front portions of the cerebral cortex, is now called Broca's area. In Broca's aphasia, speech is slow and laboured. Articulation is crude. Other characteristics of Broca's aphasia include omission of grammatical words at the endings of nouns and verbs, so that the speech has a telegraphic style. Geschwind (1972, p.78) gives the following example of Broca's aphasia: "Asked to describe a trip he has taken, the patient may say 'New York'. When urged to produce a sentence, he may do no better than 'Go... New York'". Geschwind (1972) states that this example is not simply an attempt by the patient to economize on effort, but in fact. When the patient is asked to repeat certain words and sentences, s/he has difficulty with grammatical words and phrases. Geschwind (1972, p.78) adds that "The most difficult phrase for such patients to repeat is 'No ifs, ands, or buts'".

Broca's work was extended by Carl Wernicke, a German[6] physician, anatomist, psychiatrist, and neuropathologist. Wernicke began pursuing his own research into the effects of brain disease on speech and language, following Broca's findings on language deficits caused by damage to Broca's area. In 1874, Wernicke (1874)

[6] Carl Wernicke was born in 1848 in the then Prussian town of Tarnowitz in Upper Silesia, in what is now Tarnowskie Gory, Poland.

published a paper that gained immediate attention[7]. He noticed that not all language deficits were the result of damage to Broca's area, that is, he described patients with damage in the left hemisphere outside Broca's area. Damage in this area resulted in problems that differed from the problems found in patients with damage in Broca's area of the cerebral cortex. He found that damage to the left posterior, superior temporal gyrus resulted in deficits in language comprehension. This region is referred to as Wernicke's area, and the associated syndrome is known as Wernicke's aphasia.

Aphasia described by Wernicke is very different from that of Broca's. In Wernicke's aphasia, the patient may speak very rapidly, preserving rhythm, grammar, and articulation. Thus, the patient's speech, if not listened to closely, would appear to be normal. The speech, however, is abnormal because it is greatly devoid of content. The patient does not use the correct words. Instead, s/he uses circumlocutory phrases and empty words. An example of this would be the statement "Give me that thing you use to hit with" for "Give me the hammer."

There have been other cases of aphasia. For example, Geschwind (1972) describes a fascinating case of aphasia in a woman who suffered brain damage as the result of accidental carbon monoxide poisoning. During the nine years Geschwind studied her, she was totally helpless and required complete nursing care. She never spoke spontaneously and showed no evidence of comprehending words spoken to her. On the other hand, she was able to repeat sentences that had just been said to her. In addition, she would complete certain phrases. Geschwind (1972, p.80) gives the following example:

> If she heard "roses are red", she would say "roses are red, violets are blue, sugar is sweet and so are you". Even more surprising was her ability to learn songs. A song that had been written after her illness would be played to her and after a few repetitions she would begin to sing along with it. Eventually she would begin to sing as soon as the song started. If the song was stopped after a few bars, she would continue singing the song through to the end making no errors in either words or melody.

Geschwind (1972) made predictions of the particular part of the brain in which this woman's damage had occurred. Upon post-mortem investigation, his predictions were verified. In this case, the damage was not found in the speech and auditory regions. Both Broca's area and Wernicke's area were also intact. Instead, a large lesion was found that separated the speech and language areas from the rest of the cerebral cortex.

[7] See Wernicke (1910) and Eggert (1977) for further discussion on Wernicke's works on aphasia

Damasio and Damasio (1980, 1992) also studied the language of persons with brain damage caused by lesions and injuries. They attempted to link specific language skills with damage to specific parts of the brain. Other publications in this area have included studies of brain-injured soldiers in the 1920s and 1930s by Kurt Goldstein (GOLDSTEIN, 1939, 1963, 1942, 1948; GESCHWIND, 1974) and similar research with children by two German neuropsychiatrists, Heinz Werner and Alfred Strauss (WERNER; STRAUSS, 1940). Werner and Strauss' work at the Wayne County Training School in Michigan influenced a new generation of scholars and led to the development of the field of learning disabilities (HALLAHAN; KAUFFMAN, 1997; HALLAHAN; KAUFFMAN; LLOYD, 1996).

As a result of extensive research in this area, some progress has been made in the understanding of the brain structures responsible for language. Recent technological advances, such as magnetic resonance imagery, have made it easier to locate damaged areas in patients with aphasia. Positron Emission Tomography (PET) scans enable researchers to study brain activity of normal individuals engaged in linguistic tasks. In spite of these advances, only a partial understanding of how the brain stores, concepts, and produces language currently exists. Damasio and Damasio (1992, p.95) state that "[...] these structures will eventually be mapped and understood. The question is not if but when."

The study of the relationship between the human brain and language acquisition, however, is not without controversy and disagreement. While the biological basis of language development is strongly documented, Jacobs and Schumann (1992, p.286) argue to the contrary:

> This claim and the more general theoretical linguistic assertion that there is an innate, wholly distinct "language organ" seem, in many ways, to be default metaphors that reflect our ignorance about how language is acquired. Moreover, even if such "distinct" mechanisms did exist beyond the metaphorical level, they would still adhere to neurobiological fundamentals because they would be composed of neurons (= nerve cells), neuroglia (= support cells for neurons), and synapses (= the communicative junctions between nerve cells). There is in fact no neurobiologically justifiable reason to believe that learning in non-humans is either anatomically or physiologically different from learning in humans.

According to Jacobs and Schumann's (1992, p.287) basis of neurobiological perspective,

> Unlike the formal linguistic perspective, a neurobiological approach does not consider human language acquisition to be fundamentally different from the learning of any other type of knowledge (in any other species). Learning, in its most general sense, involves alteration of the microanatomical and molecular neural structure to the point where information can be retained and retrieved so as to be able to effect behavior. Although different species do not learn the same things, it is the same type of neural tissue, following the same natural laws, which makes this learning possible.

Considering the complexity of the adult human brain, it is no wonder that much is still left to be discovered about its functions. The adult brain has more than 100 billion neurons (SHATZ, 1992). These neurons are intricately connected with one another in ways that make memory, vision, learning, thought, and language acquisition possible. Shatz (1992, p.91) states that "[...] one of the most remarkable features of the adult nervous system is the precision of this wiring. No aspect of the complicated structure, it would appear, has been left to chance."

Further, the link between brain functioning and the learning of a new language also suggests that language development might be hindered by negative factors in a person's environment. For example, Hallahan and Kauffman (1997) argue that just as an athlete's performance in a competitive event might be hindered by poor nutrition and poor health practices, brain functioning might also be hindered by these same factors.

Discussion

There is strong evidence of a biological foundation to language development. Extensive research has been conducted documenting the linkage between specific components of language functioning and corresponding areas of the human brain in which it is based. The works of Broca (1861a, 1861b), Geschwind (1972, 1974), Goldstein (1939, 1963, 1942, 1948), Werner and Strauss (1940), and Wernicke (1874, 1910) leave little doubt regarding the role of the brain in the acquisition of language. Of the three theory models of language acquisition and development, the behavioristic would seem to place the least emphasis on biology in the development of language. However, Broca, Wernicke and other neuroscientists have presented convincing evidence that language has a strong neurobiological basis.

The psycholinguistic perspective seems to be congruent with the idea that there is a large innate or biological component to human language. According to the psycholinguistic perspective, the human brain possesses a language acquisition device and language is acquired through the operation of this device and interactions with the environment. The work of the scientists and neuropsychiatrists discussed in this paper certainly support many of the ideas of the psycholinguistic perspective.

The interactionistic perspective is also congruent with the idea that there is a large innate or biological component to human language, because interactionists recognizes the importance of both the learner's innate or biological abilities and the learner's linguistic environment. While the biological foundations of language are well documented, the learner's environment has a vital role. Research conducted by Curtiss et al. (1974) on Genie, the girl who was isolated until the age of 13, certainly suggests that language does not develop in a linguistic vacuum.

Nevertheless, the study of the relationship between the human brain and language acquisition remains controversial. Jacobs and Schumann (1992) maintain that there is no neurobiologically justifiable reason to believe that learning in non-humans is different from learning in humans, and that a neurobiological approach does not consider human language acquisition as fundamentally different from learning any other type of knowledge in any other species.

This contention of Jacobs and Schuman (1992), that language learning is not different from learning any other types of knowledge, runs counter to the discussion in this paper on how language can not be acquired after puberty whereas there is no particular age for developing some other skills. For instance, as discussed above in the case of Genie, would she, at the age of 13, not be able to learn to ride the bicycle just as she was not able to acquire language features? It appears that more research could be employed to accurately determine whether the human brain is biologically provided with a language acquisition device.

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■***RESUMO**: O estudo de como uma língua é adquirida e a participação do cérebro no processo de aquisição de línguas é importante, porque o desenvolvimento da linguagem é um dos fatores mais importantes no desenvolvimento humano. A análise do desenvolvimento de línguas está intrinsicamente conectada à percepção de como os seres humanos ou cérebros*

humanos percebem, aprendem, controlam e coordenam o comportamento elaborado. Dessa forma, o estudo do desenvolvimento de uma língua envolve pesquisa sobre o desenvolvimento motor, perceptual e cognitivo. Este artigo revisa as três principais teorias da aquisição de línguas, ou seja, as teorias behaviorista, psicolingüística e interacionista, e examina o componente biológico da aquisição de línguas e a participação do cérebro no processo de desenvolvimento de línguas.

■***PALAVRAS-CHAVE:*** *Aquisição de primeira e segunda línguas. Período crítico para aquisição de línguas. Danificação cerebral.*

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