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Review Article

Brain Neural Network and Language Skills

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Abstract

Brain studies in the neuro-linguistic field has developed a lot and today starting from prenatal development brain can be studied in a safe and ethical way. The research findings in phonology, morphology and lexicology provide a number of evidence-based findings for developmental psychologists, psycholinguists, educationalists, and other scientists to assist in numerous human capacity building activities. The objective of this review is to elaborate the importance of early language acquisition and the related neural networking in the brain leading to latter language skills development in humans.

Keywords: *Language Acquisition; Native Language; Second Language; Bilingualism; Brain and Language Skills; Broca and Wernick Area*

Introduction

The famous philosophical dictum of the 17th century English empiricist John Locke *Tabula Rasa* gave a temporary solution to empiricists to some of their challenging epistemological questions; nevertheless, it created a never-ending debate among nativists and empiricists that spread to various other fields like biology, neurology, evolutionary psychology, anthropology, linguistics and, among the proponents of artificial intelligence. Scholars in Epistemology and Psychology who adhere to the empiricist's view believe that a child is born into this world with a plain slate (*Tabula Rasa*) and the reaction to sensory stimuli from the environment initiate writing in this plain slate. On the other hand, the nativist philosophy asserts that certain concepts are innate at birth. This debate, popularly known as nature-nurture controversy in the social science circles, has taken new forms among neuropsychologists and it has spread to many domains today [1]. The 19th century challenge of the American psychologist J. B. Watson, "Give me a dozen healthy infants, well-formed, and my own specified world to bring them up in and I'll guarantee to take any one at random and train him to become any type of specialist I might select - doctor, lawyer, artist, merchant-chief and, yes, even beggar-man and thief, regardless of his talents, penchants, tendencies, abilities, vocations, and race of his ancestors" (1930) ignites the debate further into modern learning process too [2]. On the contrary, some developmental psychologists as well as classical psychologists backed by nativist epistemology of Kant and Descartes insist on the innate ability of human brain and the transmission of knowledge through genes.

All human society has their unique language system to communicate. The capacity to acquire language is one of the innate abilities of humans. Children are born with some basic neural presupposition to acquire the means of communication through verbal language at a very early stage of their development [3]. It is evident that mentally healthy children are able to use the grammatical structures of the language of the community in which they are born and brought up without much extra efforts. The process of language acquisition is guided by the brain and the cognitive neural network from the very early stages of development. On neutral ground one can argue that the non-ability of animals to comprehend human language *ipso facto* implies that specific neural networking in human brain contributes to the language acquisition and the geographical location, the cultural environment in which a child is being raised contributes further. However, scholars find it difficult to explain how children in their very early age master the complexity of language, specifically their native language. The nature-nurture debate on language acquisition therefore should not be focused on nature-nurture per se but should be on the magnitude and the extent of influence human brain receives from either genetic or environmental factors.

Psycholinguistics is a field closely related to neurology which studies the psycho-neurobiological factors of language acquisition. By the use of technology, it is possible today to get a clear picture of the process of language acquisition and the language learning in the brain [4]. Language acquisition and language learning are two different things. Without understanding the basic grammar, through some non-conscious process children acquire language from the people they acquaint, mainly through hearing. This is how the native language or the first language is often learned. It is more of a spontaneous activity. When brain rapidly develops in children, in the first few years of life, this native language acquisition is at its prime in the brain than in an adult brain. In learning a language, the grammar and other basic elements are understood and comprehended, and a person communicates. Both these two activities are controlled by different forms of neural activities in the brain.

Brain and Language

Language processing in the brain is concentrated into two main areas, namely, Broca's area in the left frontal cortex and the Wernicke's area in the left temporal cortex. There is no debate on the fact that the major language networks are centred on the left hemisphere of the brain. The two specific language parts of the brain are known in the name of the pioneers who did remarkable discoveries in the field; Paul Broca, a French neurosurgeon in the 19th century identified a lesion in the left inferior frontal cortex of a patient who had difficulties in speech and, Carl Wernicke, a German neurologist of the same century discovered lesion in the posterior portion of the left temporal lobe that made the patient speak incoherently. Thus, these two areas of the brain and their neural networks are named after the neurologists who identified them as the primary centres of language. The Broca's area, in connection with the motor cortex in the brain produces language and the Wernicke's area processes words and comprehends them. Although Broca area together with the motor cortex, and Wernicke area are primarily involved in language acquisition and learning, these dedicated brain areas work in regular contact with other cortical networking areas for various cognitive processes related to language, comprehension and communication [5]. Though there are biological and utility similarities between humans and nonhuman primates in these specific areas of the brain, unlike the animals, in human brain, the sizes are larger with more number of neurons and they differ in their neural networking also [6]. The Broca area and Wernicke area are networked through arcuate fasciculus nerve connections. This bundle of axons is either not present or substantially smaller in nonhuman primates [7]. When the arcuate fasciculus is affected or damaged, it leads to a language disorder called conduction aphasia, characterized by poor speech repetition, mainly deficiency in repeating long and complex phrases [8].

Neural processing and first language

Modern researches in the field of psycho-neurobiology show that the beginning of brain's neural network in the first year of life influences the child's life-long language development [9]. The emergence of neuroscience techniques in the 21st century has opened new vistas in understanding language acquisition and the related neural networking in the brain. However, the complex phenomenon of acquiring a language rather effortlessly at an early stage of human development still remains an unsolved mystery among linguists, developmental psychologists, neuropsychologists and neuroscientists. Electroencephalography (EEG), Magnetoencephalography (MEG), Event-related Potentials (ERPs), functional Magnetic Resonance Imaging (fMRI), and Near-Infrared Spectroscopy (NIRS) are few of the notable non-invasive techniques that help neurologists in studying language related brain activities [9-13]. Studies using these sophisticated modern techniques identify a complex neural networking that develops in the brain during early acquisition of first native language or, often referred to as mother tongue or home language. Newborns easily acquire any language to which they are exposed; the ease with which they acquire language decreases as they grow older. It is due to the fact that age six or seven is the period brain and its neural connections reach some basic maturation and therefore this period remains the cut-off phase between early and late bilinguals [14]. It is on the patterns of early language all future learning is established [9]. There are empirical evidences to prove that the basic elements of early language are crucial in the cognitive development.

Human language acquisition and learning start by hearing. Therefore, the language centres are closely linked to other sensory cortex in the brain to assist the process of language acquisition and learning. Each language has its own distinct units of sound which is called phonemes. In the language acquisition process, before acquiring words, children pickup these sounds and the brain try to differentiate them. Studies also prove that the innate skills contribute a lot in this phonetic learning [9]. Brain's neural networks create patterns slowly and steadily as the child acquire more and more sounds and words. Kuhl's Native Language Magnet or Neural Commitment Theory explains that this neural dedication alters the brain's neural networks at the very early age and conditions the brain to the native language that is being acquired [15,16]. This neural commitment based initial coding of native-language affects the learning of any new language in the later period of life, even making it harder due to the initial neural tie-up. Therefore, the first language of the child creates a lasting imprint in the brain and only through this medium future learning takes place. Building on this hypothesis, we can also presume that the native language plays a pivotal role in the various other cognitive skills and competitive ability of the adult as well.

Second language learning

Studies highlight that brain processes a second language using the existing first language network, also using additional brain areas. A meta-analysis that examined the neural network and the factors involved in the first (L1) and second language (L2) acquisition and the age of acquisition identifies that L2 processing involved more additional regions and it is more demanding than L1 in late bilinguals compared to early bilinguals [17]. Joy Hirsch, Professor of Psychiatry and Neurobiology at Yale University and her colleagues found that the native and second language (language that is learned separately) are spatially separated in Broca's area; however, the two languages show very little separation in the activation of Wernicke's area. In other words, children who learn many languages simultaneously at an early stage of language acquisition have a single region in the brain that activates language related activities, whereas people who learn a second language in adolescence or latter possess two separate brain regions for languages [18]. These findings explain why it is difficult to learn a second language as an adult. Since the Broca's area is primarily devoted to the first language, an additional Broca's region is formed for the additional language. However, the first language's neural networks are the basic medium by which the brain tries to communicate the second language, even if the first language is no longer spoken [19]. Therefore, it is the first language's neural networking that the brain uses for later language learning.

In this regard, there are different types of bilingualism. The simultaneous early bilingualism is that in which a child learns two or more languages from birth; it is also called strong bilingualism. The father's family talks one language, mother's family talks another language and the maid that takes care of the baby talks yet another language and the child has no difficulty speaking or mastering these languages as a first language. Successive early bilingualism is yet another way of mastering two languages in which a child who is acquiring a native/home language is forced to learn a second language if the family moves to a new place and culture. This is also a strong bilingualism however the child takes some time to learn the second language. Another bilingualism is that in which the second language is learned later than the age of 6 or 7 or as an adolescent or adult, it is labelled as late bilingualism or coordinate bilingualism. There is also passive bilingualism in which a new language is understood by mere acquaintance not by any learning or efforts. It is noteworthy that the neural network in the brain of a child with strong bilingualism and people with late bilingualism are different [20]. Linguistic knowledge is high in children who hear and acquire two languages than children who hear and acquire only one language. Since the language input is divided between two languages they tend to lag in vocabulary and grammatical development when compared to monolingual children of the age [21]. Strong or dominant bilinguals work from separate phonological inventories in the brain and therefore they will have better mastery and control over the language whereas late bilinguals have one common speech sound system for the processing of their different languages [22].

Unique languages

The episode of Professor Tsunoda of Tokyo Medical and Dental University's visit to a conference at Havana in 1987 gives some insights on language and brain. While listening to a lecture at Cuba, Tsunoda was distracted by the sound of some unknown insects. To the surprise of Tsunoda, none of the Cuban delegates noticed the sound or being distracted. Confused by this unusual distraction and the related phenomenon, Tsunoda started to research on the physiological differences in the neural networking of Japanese brain. His findings were extraordinary; for most of people, the sound of insects is processed by the brain in the music part, in the right hemisphere; whereas Japanese brain process the insects sound in their language area in the left hemisphere (Ise, 2002). Since Japanese brain process the insects sound in the same language area similar to human voices, Tsunoda was distracted by the sound of the insect during the lecture. While the brain processes human speech, if the insect sound is heard simultaneously, the brain is confused in giving processing priority. The Japanese brain processes all natural sounds in the language sphere in the left hemisphere of brain and the onomatopoeia (creating a word that phonetically imitates the sound that it describes) in the language paves the way for this unique neural networking in the brain. Further studies also reveal that the Japanese people who live in America, who had either Spanish or Portuguese as their first language, have their brain's neural networking in the Western pattern, not in the classical Japanese style (Ise, 2002). According to Tsunoda, some Polynesian languages also show similarities like Japanese language patterns [23].

Conclusion

Human language is a highly developed cognitive activity. Due to innate brain disposition, children at an early age are able to acquire language skills easily. The language related neural activities are centred on the left hemisphere of the brain mainly Broca's and Wernicke's areas. However, various other parts of the brain coordinate for language comprehension and communication. Unlike the olden days, today technology offers many non-invasive techniques to help neurologists and other scholars in studying the language related brain activities. The first language or the native language acquisition plays a pivotal role in language related neural networking in the brain. The learning of second language or bilingual ability is possible even in the adult stage. The early learners have a higher advantage in bilingualism because the brain is tuned in such way that by age six or seven language related natural neural networking is somewhat established. In this way, the native language or first languages play an important role in the brain and its cognitive functioning.

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