Evolution of Human Language – A Biolinguistic, Biosemiotic and Neurobiological Perspective

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Language in India www.languageinindia.com **ISSN 1930-2940 Vol. 13:6 June 2013**

Abstract

An attempt is made here to approach the origin and evolution of human language from the foundational perspective of the faculty of language as a species specific attribute, found nowhere else in the animal kingdom. The rebirth of cognitive psychology started with Noam Chomsky as a major development in attempting a scientific basis of the understanding of language with a major empirical basis in neurobiology and neuroethology. While the study of language still remains a challenging area for philosophical and methodological debate, it enlightens many new areas of cognitive psychology and sets many new neuroscientific agenda for future research.

The biolinguistic, biosemiotic and neurobiological perspective focuses the origin of language problem as a working programme to find fruitful answers to many questions in neurology and attempts solutions to correct many language disorders in clinical practice.

Introduction

Despite a number of theories and approaches proposed to explain the origin of language in humans (Afzal et al 2007, Nehal and Afzal 2012) the basis of language generation and development in human remains a mystery (Smith and Kirby 2008). Tremendous advancements in the field of neurology, psychology, developmental genetics, computer science and engineering have addressed different fields of language and communication research and many questions of biology, psychology and medicine are being solved (Christiansen and Kirby 2003).

However, a comprehensive theory of evolutionary linguistics still remains to be attempted (Witzanky 2011). It appears that language research provides a crucial juncture for many fields to explore the brain functioning itself and the complex interface of gene, brain, behavior and language axis is involved, having an evolutionary course of making the genetic tool kit and hence meet with the functional and developmental requirements to fulfill this important task in an effective manner (Margoliash and Nisbaum 2009).

Until a unanimous theory of language is developed, the epistemological and methodological issues will continue to surface for a complete deciphering of the linguistic code (Mondal 2012). This paper will address these issues through three approaches – a biolinguistic, biosemiotic and neurobiological perspective of language structure which can shade some new light on nature and method of language study itself.

Biolinguistics

The main concern of language as an internal faculty of the organism to respond to the challenges of the environment, as are the genetic, immunological and behavioral outputs, is considered a primary faculty which helps in adaptation to the environment. Hence it is an internal trait which led Chomsky (1957) to consider it as language organ and Pinker (1994) to consider it as innate core and basic to evolutionary development.

The biolinguistic approach is a great success as the developments in genes, developmental pathway and behavioral disorders led biologists to search the language roots in evolutionary past, hence proto-language, fossil language, language genealogies and many approaches in language study emerge and the main engine for language research in biolinguistics is provided by Chomsky's generative grammar (1965) which, though powerful, has still many limitations.

(i) The genetic constraints of evolution predate the evolution of language and all animals despite the sharing of genes couldn't develop language.
(ii) The computer simulation studies suggest that cultural evolution is far more effective in language evolution than biological adaptation (Berwick 2009).

(iii) The universal grammar might have originated as a complex organ like visual system through Baldwin effect (1896, 1897). The Baldwin effect has been called organic selection, which explains callus and sterna of ostrich. The characters more used are genetically assimilated and inherited.

(iv) Simulation studies by Christiansen et al (2002) have addressed this question. In one experiment, learners of language who are biased toward learning a language, differentially reproduce and language learning is internalized in the genome. However this is unlike the visual system, as the visual environment is less changing while the language environment is changing fast.

(v) Under rapid linguistic change, genes can't evolve fast enough, to keep pace with the moving target.

(vi) Coevolution of gene and language can also occur, simulation studies further show that gene-language change can occur only if genetic pressure is extreme or coevolution can occur only if language is entirely genetically coded. This is not possible.

(vii) On these grounds, universal grammar couldn't have evolved on evolutionary grounds. Only cultural evolution can explain it.

Biosemiotics

A very different approach to evolution has been suggested by biosemioticians, the importance of which has attracted attention of a number of serious scholars of linguistics. We have here a powerful group of scholars who have argued for a primary vesus secondary organizer module of language. Marcello Barbieri (2010) has tried to resolve the conflict between Thomas Sebeok and Noam Chomsky in biosemiotics. He first traced the similarities between the two scholars thus –

a) Language has biological roots.
b) Language is a faculty, a modeling system.
c) Recursion is the basis of generating unlimited number of structures from a finite set of elements.
d) Innate faculty to acquire language lies within a few years.

However the difference is centered around the cognitive development and the brain – wiring which is prolonged in human ontogenesis unlike the case in other mammals viz. embryogenic, foetal, infant and child development which has prolonged span and in the heterochrony of '*cerebra bifida'*, the development of brain is followed by the development of language (though only after birth).

The biosemiotics of language is an extension of the famous semiotic theory having an innovative attempt toward science of semiotics itself, from –zoosemiotics (including animal life), to life and code semiosis which are extenstive and it is essentially triadic (observer-object-interpretant, Pierce 1906), instead of Saussure's diadic form (1916). Chomsky similarly had major innovation in the study of linguistics viz. he replaced behaviorism of Skinner (1959) with modern cognitive base, introduced innate and generative type of universal grammar (1959) and a common program of the principles called minimalist programme (1995).

While Sebeok (1979, 1991) placed interpretation as the chief feature of language, Chomsky placed syntax as governing the meaning with simplicity and economy of words, a principle to be discovered like principle of least action in physics or periodic table in chemistry.

Modern linguistics separates so-called external language (E. Language) and internal language (I.Language). The former has two components – the phonetic one (to receive and produce sound) to cognitive system (gives meaning to it), to which a third is added, i.e., syntax which is a processing system evolved only among humans. Hauser et al (2002) gave twofold classification thus – FLB (broad sense) and FLNS (narrow sense) which is syntax alone. In bio-semiotics the animal perceives the world through a subjective environment 'unwelt' which is species specific. This unwelt is perceived by 'innenwelt' (Uexkull 1909) which is primary modeling system. Thus, animals and man have similar primary modeling system, but not language (Lotman 1991), human language is the result of a later evolutionary addition, the secondary modeling system (this is so to say the FLN of Chomsky, though more evolved one).

The biosemiotic approach to the evolution of language has been perfected by Marcello Barbie (2003), as a system of organic code which evolved in the living world since the first cell evolved. The ribo-world is the unique prebiotic world that had a trinity of genotype, phenotype and ribotype. This starts in the beginning with genetic code as a pure code (code semiosis) and later on as interpretative code (hermeneutic semiosis). Semiosis is the production of signs and meaning with independence between them (there is no necessary link between the two).

A semiotic system is a system of two independent worlds connected by the convention of code. Hence semiotics has three entities – the sign, the meaning and the code. Furthermore, there is a code maker (agent) which makes all these three.

In the primitive world before cell, there were only molecules and bondmakers (agent) that joined molecule by chemical bonds, there being a template and making of the copies of nucleic acids. Proteins couldn't be made by copying and required four types of molecules, the DNA, a carrier of genetic information (a messenger RNA), a peptide bond maker (a piece of ribosomal RNA) and molecules that carry both the nucleotides and amino acids (transfer RNA), the remarkable feature of protein makers was that there had to be a strict correspondence between genes and proteins and the evolution of translational apparatus had to go hand in hand with the evolution of genetic code.

Protein synthesis then arose due to integration of two distinct processes – the code itself and the template – dependant peptide maker or a codemaker. The ribosoids provided this codemaker and are the oldest of the phylogenetic molecules; the genes, proteins and ribosoids are all manufactured molecules, only ribosoids are makers of these molecules; cells have thus three types of entities – genotype, phenotype and ribotype (codemaker). Thus cell is a true semiotic system and code semiosis is a reality. From this, Barbieri (2003, 2006) concludes that organic code or code semiosis has three features – a) organic codes exist by the presence of adaptors and are universal (b) the presence of two or more organic codes show context – dependant behavior of cells and there is no need of interpretation at the cellular level (hence two types of biosemiosis – one depends upon coding and one depends on interpretation) and, finally, c) in a new great step of macroevolution, the appearance of new organic codes took place.

The biosemiotic approach thus sees the evolution of language as precise and devoid of any interpretation and the syntax, if any, has to be based on organic codes rather than requiring more universal laws of Chomsky ala periodic table, or principles of least action.

Code Model of the Origin of Language

In the first step, the code model of the origin of language has been developed by anthropologists and semioticians identifying three features of signs (languages) – a) sign is an icon of object, viz., a tree, mountain, etc b) the sign is an index associated with an object, viz., cloud with rain and c) sign is a symbol; a flag of a country where no physical link exists between the two. While animal communication is solely based on icons and indexes, human language is based on symbols (Deacon 1997). Hence animals have no symbols.

Sign

This is because animals have only one modeling system, which is also found in humans. This modeling system is based on building a mental world out of a real world, and the Natural selection is a process which helps animals to reduce the gap of reality. Animals are able to do it by icons and indexes because they represent physical properties; they do not use symbols as symbols are arbitrary and increase distance from reality. This is the base of so-called primary modeling system. However, man has a secondary modeling system too which is based on symbols.

Pedogenesis and Late Embryonic Period

This second system is the result of man being a juvenile ape (fetalization theory of Louis Bolk 1926). Animals have developed embryonic life such as pedogenesis, neoteny and pedomorphosis. While humans have horizontal line of sight while standing erect, primates can look around while walking on all four (Gould 1977). The Evo-devo approach is called for (Kanopka and Geshwind 2010) as bigger brains, flat faces, reduced body hair and upright postures are all present in foetal stages of all primates but extension of these features in the post-uterine period is only a human feature. Hence for language no new genes are required for the larger size of human brain, only late embryonic period is enough for the brain

development. Man in fact needs twenty one months of intrauterine life for development of complete size of the brain, so this large brain development outside uterus is an innovation to escape the limited uterus size and narrow space of the birth canal. New brain – wring is thus the basis of language development in man. This brain wiring is subject to environmental interaction between child and other individuals and hence language could develop only among humans.

Marcello further cites the example of *Cardia bifida* in the development of two hearts in a single circulatory system in a developing embryo, as the two primordial diverticula coming together beside the gut, fail to fuse due to physical separation, say by means of a flap of an object, and form two hearts epigenetically. In case of language too, animal genes (similar with man) are epigenetically regulated to provide language development (no new genes are required).

Postnatal Development and Language

Jean Piaget's (1954, 1960) postnatal development of cognitive abilities (object, space, time, causality, number, word) has four elaborate stages, viz., – sensory motor, preoperational, operational and formal. No new neural connections are formed in all these periods – only intensity of the wiring tends to decrease. The brain ignores most incoming signals, but it allows human interactions that take place in first few years of postnatal development. The wiring of nervous system is achieved by an overproduction of neurons followed by elimination of those which don't come in contact with nerve growth factors (Changeaux 1983, Edelman 1987). The programmed cell death (apoptosis) is activated by molecules of death – however in case of language, not internal growth factors are required, only external factors of the human interactions are enough. Thus the genes of language are the same as genes of modeling system in animals but here the codemaker is not individual brain but the community of interacting brains (so-called distributed language, Cowley 2007).

Conclusions Relating to Code Origin of Language

A few conclusions are reached here for the code origin of language –

(i) Origin of language was due to a small set of new codes (foundation).

(ii) Evolution of language was due to appearance of other codes at various stages of development and finally the foundational codes were strongly conserved and remain as the language faculty of all human beings.

Neurolinguistic View of Language

Evolutionary inquiry on generation of language as listed above lack a further mechanistic component of language to be studied empirically, particularly in case of syntax which is related with subdomain of language. Neuroanatomic and neurophysiological research is concerned with language processing, finding neuronal pathways and their local circuits from infrastructures of speech and language. This includes mapping from gene to brain circuit to linguistic phenotype at the level of computational operations.

Science of Comparative Ethology

The science of comparative ethology has a working programme on the communication and cognition research. In language processing, what factors of non human species can be taken as conserved? This requires language processing (viz., phonology, syntax, semantics) to be decomposed into more elementary operations viz. concatenation, labeling and constituent construction.

There are two different foundational perspectives on language as a computational system for communication versus language as a system for optimizing communication.

Language is used for communication- but not necessarily optimally designed for this purpose. The optimal path is, psychologically speaking, more concerned with combining constituent thoughts, generating new internal representation (Chomsky, 2000). These are the so-called two aspects of language not yet understood properly.

In genetics, linguistic behavior has a gene – brain behavior linkage, which has been elaborated as mapping from genetics to neural circuitry to computational neuroscience to language processing (David Poeppel 2011). Much progress has been made in this regard.

This in the past years required a threefold approach a) the functional anatomy of language, b) physiological data on timing, and finally c) the analytic relation of the language and neurobiology, the so called granularity mismatch problem.

The division of brain into Broca's area in the left inferior frontal lobe and Wernicke's area in the posterior superior temporal lobe has been associated respectively with production (syntactic aspects of language) and perception (meaning) of the signal. This was reflexive, as held earlier, now only it is taken as there being internal representation/computations as 'mental operation' (data generated through fMRI, PET, EEG, MEG etc point out that there are many more cortical and sub-cortical regions beyond the left and right hemispheres implicated in various tasks).

Some interesting features are noted here.

a) **Information Processing**

There is a dual stream of information processing (Poeppel and Hickok 2004). For speech recognition, acoustic signals are initially analyzed in the dorsal and posterior superior temporal gyrus and superior temporal sulcus. These initial stages of perceptual analysis are computed bilaterally in the superior temporal cortex (Binder et al, 2000), there being computational specialization between the two (timing properties).

From this two streams originate: a) A ventral pathway (superior temporal sulcus, anterior temporal lobe, middle temporal gyrus, inferior temporal sulcus and inferior temporal gyrus), this stream gives sensory/phonological representation to lexical or conceptual representation (i.e., from sound to meaning). b) A dorsal pathway include Sylvian pareitotemporal area, inferior frontal gyrus, and anterior insular premotor cortex provide substrate for mapping from sensory/phonological representation to articulatory motor representation. The early analysis is bilateral (ventral one is more bilateral) and dorsal pathway is more left – lateralized. (There are further many fine grained subdivisions).

Here it may be noted that these regions are not given to entire syntax phonology, rather to distributed elements – the base of recognizing words, words to phrases and phrases

to sentences. Processing is further related to cognitive domains and spatially decomposed into sub routines.

b) **Time Resolution Processing**

There has been extensive behavioral and neurophysiological research during last ten years, that show that processing happens on multiple time scales concurrently, as asymmetric sampling times (AST) as high rate (25-50 Hz) and at lower rate (below 8 Hz). This allows processor to analyze lexical information at one scale and rapid phonemic information at the other. Genetically, selective dysfunction of the circuit for slow sampling induces dyslexia, leading phonological representation poorly mapped to othrography, and poor reading performance. Similarly optogenetic techniques (Sohal et al 2009) show that cell types can regulate gamma band activity and sensory processing important for speech recognition and hence provide a basis for processing linguistic representation of particular grain size (segmental information).

c) Granularity Mismatch Problem

A major problem of cognitive neuroscience is the relationship between alphabets of neuroscience (viz. neuron, synapse, oscillation, long term potential) and alphabet of language viz. syllables, noun phrase, question formation, etc. this is not an easy question to be answered. In linguistics, language has the adult speaker/listener with acquisition of language as fine-grained trait whereas in neurobiology, the real phenomena are to find where lies the actual syntax. This is a granularity mismatch problem.

Linking these two areas requires computational analysis. This requires a task, a way for word recognition and mapping it into circuits that can be related to nervous tissues. This reduction is still not easy, for we do not know if a syllable maps on a dendrite, neuron, assemble, cortical column or some assembly of parts. An important concept is concatenation (like X and Y generate X-Y) or linearization and how is it linked to mind or the circuitry, underlying the gamma band which is related to speech.

This type of correlation between neurobiology and language comprehension provides a tool to approach genetic and evolutionary study of language which can further lead us to

explain bigger categories as syntax or even communication. Such concepts as concatenation and rapid sampling can also give us tools for computational routine aberration to language pathology which can lead us to a better use of language related disorders. The task is to decipher appropriate computations and granularity to approach the issue for evolutionary, genetic or epigenetic explanations as suggested by biolinguistic or biosemiotic approach.

Conclusion

There are, thus, three aspects in evolutionary linguistics to which the common points of language research (however diverse these three adaptive systems be), are linked (Simon and Kirby 2003); the evolutionary wherewithal (the toolkit), the language learning (infant stages) and the cultural transmission (necessary for social interaction). The complexity of language structure and function is based on the triad of time scale which is hallmark of language faculty among humans. A universal theme to unite all these three approaches has been attempted by universal generative grammar approach and explained by game theory (Nowak et. al. 2001), but its existence or acquisition in developing individual is still debatable. At present therefore, there is no consensus of a universal grammar or an interactive approach.

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Acknowledgement

Thanks are due to our colleagues in linguistics at Aligarh Muslim University, Aligarh for their discussion and comments and the Chairman Prof. Irfan Ahmad, Department of Zoology for giving permission for the publication of this work.

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References

Afzal M, Siddique YH, Ara G and Nehal M (2007) Origin of human language. How much non-linear is it? *Indian Biologist,* 39(2), 19-22.

Baldwin, JM (1897) A new factor in evolution, *The American Naturalist* 30, 354: 441-451.

Baldwin, JM (1897): Organic selection: *Science*, 5, 121, 634 – 636.

Barbieri, M (2006) Life and Semiosis: the real nature of information and meaning *Semiotica* 158 (1/4) 233-254.

Barbieri, M (2003) *The organic codes An introduction to semantic biology* Cambridge, Cambridge University Press.

Barbieri, M (2010). On the origin of language A bridge between Biolinguistics and Biosemiotics *Biosemiotics* (2010) 3: 201-223.

Berwick, RC (2009) What genes cannot learn about language? *Proceedings of the National Academy of Sciences* (USA) 106, 6:1685-1686.

Binder JR, Frost JA, Hammeke TA, Bellgowan PSF, Springer JA, Kauffman JA, et al. (2000) Human temporal lobe activation by speech and non speech sounds *Cerebr Cortex*: 10 (5): 512.

Bolk, L (1926) *Foetalization theory of human mind*– Das Problemder Menschwordung.

Changeaux, JP (1983) *L'Homme Neuronal,* Paris: Libraire Artheme Fayard

Chomsky, N (1957) *Syntactic structures* The Hague: Mouton.

Chomsky, N (1959). Review of verbal behavior by BF Skinner, *Language* 35 (1), 26-58.

Chomsky, N (1965). *Aspects of the Theory of Syntax*, Cambridge MA, MIT Press.

Chomsky, N (1995). *The minimalist program* Cambridge MIT.

Chomsky,N (2000). *New horizons in the study of language and mind*. Cambridge: Cambridge University Press.

Christiansen, MH and Kirby, S (2003). *Language Evolution* Oxford University Press.

Christiansen, MH et al (2002): The role of sequential learning in language evolution: *Computational and experimental studies simulating the evolution of language* (Congelosi A, and Parisi D eds) pp 328-340. Springer Verlag.

Christiansen, MH and Kirby, S (2003): Language Evolution: Consensus and controversies. *Trends in Cognitive Sciences*7,7:300-307

Cowley, SJ (2007). How human infants deal with symbol grounding. *Interaction Studies* 8 (1), 83-104.

Deacon, TW (1997). *The Symbolic Species: The co-evolution of language and the brain.* New York: Norton.

Dettaan, RL (1959) *Cardia bifida* and the development of pacemaker function in the early chicken heart. *Developmental Biology* 1, 586-602.

Edelman, CM (1987) *Neural Darwinism. The theory of neuronal group selection.* New York, Basic books.

Gould, SG (1977): *Ontogeny and Phylogeny* The Belknap Press of Harvard University Press.

Hauser MD, Chomsky N, Fitch WT (2002). The faculty of Language; what is it, who has it and how did it evolve? *Science* 298, 1569-1579.

Konopla, G and Geshwind, DH (2010). Human brain evolution: Harnessing the genomics, (r) evolution to link genes, cognition and behavior *Neuron*, 21, 68(2): 231-244.

Lotman, J (1991) *Universe of the Mind: A semiotic Theory of Culture* Bloomington, Indiana University Press.

Margoliash, D and Nusbaum, HC (2009). Language: The perspective from organismal biology. *Trends Cogn Sci* 213 (12): 505-510.

Mondal, P (2012): Can Internalism and externalism be reconciled in a biological epistemology of language? *Biosemiotics* 5,1:1-22.

Nehal M and Afzal M (2012); origin and evolution of human language – A brief survey of some theories and approaches. *Language in India* 12:108-122.

Novak MA, Komarova NL and Niyogi, P (2001): Evolution of universal grammar, *Science* 291,5501:114-118

Piaget, J (1954) *The Construction of reality in the child,* New York, Basic books.

Piaget, J (1960) *The Child's conception of physical causality*. Paterson: Littlefield Paris: Libraire Artheme Fayard

Pierce, CS (1906). The basis of pragmatism In C. Hart Shorne and P. Weiss (Eds) *The Collected papers of Charles Sanders Pierce* (Vol I-VI, pp 1931-1935). Cambridge: Harward University Press.

Pinker, S (1994). *The language instinct*, London Penguins.

Poeppel D, Hickok G (2004) Towards a new functional anatomy of language *Cognition* 92 (1-2):1-12.

Poeppel, D (2011) Genetics and language: a neurobiological perspective on the missing link. *J. Neurodevelop Disord* 3: 381-387.

Saussure, FD (1916) – *Course de linguistique generale* ed. C. Bally and A. Sechehaye,

Sebeok, TA (1979) *The sign and its masters, Austin,*: University of Texas Press.

Sebeok, TA (1991). *A sign is just a sign,* Bloomington, Indian University Press.

Skinner BF, (1938). *The Behavior of Organisms*: An Experimental Analysis.

Smith, K and Kirby, S (2008). Cultural evolution: implications for understanding the human language faculty and its evolution: *Phil. Trans. R. Soc.* B 363, 3591-3603.

Sohal VS, Zhang F, Yizhar O, Deisseroth K (2009) Parvalbumin neurons and gamma rhythms enhance cortical performance *Nature* 459: 698-702.

Von Uexkull, J (1909) *Umwelt and Innenwelt der Teire Berlin*: Julius Springer.

Witzany, G (2011) Can mathematics explain the evolution of human language? *Communication and Integrative Biology* 4:5, 5K-520.

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