

CAN CLIMATE INSTABILITY EXPLAIN HUMAN SPECIATION AND LANGUAGE EVOLUTION?

*Svetlana T. Davidova

ABSTRACT

Adaptation to the current environment is the fundamental principle of evolution and climate is the cornerstone in the formation of this environment. In the last 2 million years (my) the earth has experienced radical fluctuations of climatic patterns which triggered radical changes in ecology. Many species have adapted to these extreme conditions by evolving higher intelligence. This general tendency is manifested most clearly in the evolution of the homo branch of primates and homo sapiens by the evolution of larger brains resulting in elevated learning capacity and creative problem solving and innovation, identified by some scholars as the most distinctive characteristic of our species. In this context the article argues that language can be defined as a repository of knowledge and a tool for preservation, accumulation, dissemination and creative reuse of knowledge and previous experience in stimulating future innovation.

The origin of language is understood as behavioural innovation which, given its adaptive utility, triggered interaction of biological and cultural evolution resulting in a human language faculty as innate predispositions for effective learning the basic aspects of language, both meaning and structure, most essential for its primary function of knowledge preservation and dissemination. On the other hand, the grammatical and semantic idiosyncrasies demonstrated in language diversity are explained by cultural evolution of languages in service of social and cultural identity of the communities.

Key words: climate change, human speciation, evolution of language, Language Faculty, innovation

1. INTRODUCTION

The concept of evolution refers to a specific type of change in organisms, intergenerational change by inheritance and natural selection as outlined by Darwin. It has offered the most plausible explanation for the presence of complex design in life forms. In Darwin's theory the diversity of life forms is explained as resulting from series of small successive modifications in the ancestral species, by which they aim at becoming maximally fit to some element of the environment. The gradual accumulation of minor modifications in each new generation of descendants lead to divergence from ancestral species into new species.

Climate is an important aspect of the environment in which species exist and to which they adapt and evolve. Climatic changes are generally gradual, triggering the usual response of gradual adaptation.

That said, there is evidence that the planet has experienced abrupt climatic fluctuations in short periods with dramatic global consequences for eco systems everywhere, from the tropics to the poles, from high elevations to low lands. "Abrupt" is defined by some (W. Calvin 2001) as measured in multiple decades while by others in centuries and even a millennium. The latest period of dramatic climatic fluctuations is determined between 2 million years (my) and

30,000 years ago (ya) resulting in dramatic alterations in multiple aspects of the natural environment, from oxygen levels to rain and water levels to seasons, affecting the flora and fauna everywhere by disrupting habitats, food sources, reproductive patterns etc. often during the life span of a single generation. These dramatic changes have affected different life forms in different ways, e.g. mass extinctions of species with short life span and anatomical, behavioural and cognitive changes in species with life span long enough to respond to these fluctuations. The Turnover-Pulse Hypothesis explains periodic mass extinctions with the influence of drastic climate fluctuations on ecosystems. (R. Potts, 1998, and elsewhere, W. Calvin, 2001). Organisms able to tolerate elevated speed of change are favoured by evolution in these circumstances.

Although the correlation between climate and evolution is still debated, a growing number of scholars seem to converge on the conclusion that climate has a strong influence on biota (R. Potts, 2013; R. Potts et al. 2018 and elsewhere). Given that the hypothesis is consistent with the general principles of evolution as tracking the changes in the physical environment of which climate is a component, in the following article I will assume without argument this to be the case.

1.1. Learning as adaptation to change

Many species have demonstrated learning capacities. Learning has shown to be a good adaptive strategy and evolution has facilitated learning and training. For example during the life span of many species there is a genetically predetermined period, usually during early childhood, when learning is facilitated. Others have been forced to find ways to alter the innate limits of their adaptability significantly by adopting new behaviours through learning by trial and error. An individual learns from own experiences, hence, individual learning. Social creatures learn from one another e.g. parents teach their offsprings, or youngsters learn from conspecifics by observation. Most species have developed learning practices at the level of the individual, thus, knowledge learned by the individual dies with it. Learned behaviours are not biologically inherited, they are learned anew by each new generation.

Many species have developed cultural practices for learning from conspecifics. Studies of avian and mammal species have demonstrated behavioural inheritance, providing evidence that cultural evolution is not restricted to humans. A well known example is the potato washing in Japanese Macaques. Some avian species are also well known for their learning abilities. (Pepperberg, 1998 and elsewhere). A concise summary of studies of animal learning abilities can be found in M. Trestman (2015).

Learning of behaviour usually happens by imitation. The individual copies the behaviour observed. Avian species and whales learn their songs by vocal imitation. Learning of behaviours is not necessarily from parent to child, the teacher can be any individual who displays the behaviour. Behavioural inheritance is quite common in the living world.

It is natural to expect that environmental instability would stimulate the evolution of extended learning capacities by the development of large brains facilitating the development of culture and learning as an effective survival tool. In fact many species have adopted such strategies given their high adaptive value despite the fact that large brains are energy-inefficient as

consumers of a large portion of the body's energy.

Given the appearance of signs of increased cognitive complexity in the fossil record during the period of dramatic increase in frequency of temperature fluctuations and climatic instability concentrated in Pleistocene, in comparison to the much slower pace of cognitive evolution during the preceding 63 my. (P. Richerson, R. Bettinger, R. Boyd, 2005), the argument for a causal connection between these two facts is plausible. This makes it reasonable for the purposes of this article to assume without further argumentation this to be the case.

1.1.1. Encephalization and cognitive complexity in primates

Elevated cognitive demands can explain the increase in brain size in hominid species, beginning with Australopithecus, a bipedal, small-brained ape with brain size of about 400 cc, who lived about 4-2 million years ago (mya) and used tools at the level of modern chimpanzee, continuing with Homo Habilis who lived in Africa about 1.9 mya. (Richard Leaky 1994). The tendency for elevated encephalization further continues in Erectus species, with brain of 850-1200 cubic centimetres (cc) or increase of more than 200%, closely resembling that of a modern human, i.e. 1350 cc (T. Fitch, 2010). Erectus was the first to leave Africa about 2 mya and disperse in Asia and beyond and is associated with the appearance of primitive tools of the Oldowan culture. The name Ergaster refers to the African branch of Homo, while Erectus refers to the Asian branch. Erectus is credited with the Acheulian culture, which remained in use for about 1 my, the invention of fire about 400,000 ya which requires a significant degree of cooperation. Most scholars attribute the beginning of language to Erectus species. Further increase in brain size is found in Neanderthals at about 1400 cc, comparable to human's.

Although scholars differ in their taxonomy of hominid and homo species, the general tendency of increase in brain size coinciding with increase of cognitive complexity is largely undisputed.

1.1.2. Primate behavioural complexity

Great apes have shown superior cognitive abilities compared to non-ape species. They demonstrate extended social learning, pass on animal traditions through imitation. Apes can learn by imitation, they are capable of self-recognition in a mirror, understand the concept of discreteness e.g. they can perceive discrete objects and events, the concept of same and different, understand abstract relationships, understand complex events as ordered actions and know when to participate in them, have some concept of group membership and can organize a war. (M. Donald, 1993, chapter Primate cognition).

Chimpanzees are among the best studied apes. They display the following characteristics: large body, large brain, long life, unusually low reproductive rate, i.e. one child at a time, long childhood, suggesting a long period of child dependence on parental care Fitch (2010, p. 238-). They are also highly social animals who live in large groups, practice toolmaking and use, hunt for meat. They also self-medicate using plants, use caves for shelter, practice pair bonding and paternal care for infants, male chimps hunt, i.e. there is some division of labour.

J. Hurford (2012, p. 119-) references reports that apes have demonstrated some, albeit limited, capacity to alter innate calls by learning. Some apes also show limited capacity for control of innate emotional calls and a stronger capacity for voluntary control of manual gestures. Thus, modern apes show some capacities to modify innate behaviours by learning. Moreover, modern primates raised in human families and exposed to the same conditions human children are raised display remarkable capacities for learning, remembering and creatively using a large number of symbols, e.g. some have earned over a hundred symbols . Chimpanzees raised in human environment learned to communicate by gestures at a level of complexity comparable to this of young children and display the same initial stages of language learning as human children. e.g. using language in dyadic performative acts and combinations of signs for concrete objects. Various studies demonstrated that chimps do not just memorize signs, they form categories and have symbolic representations of these, e.g. they use symbols in simple combinations in a meaningful way, in some cases spontaneously (Gardner, Gardner, Van Canfort, eds.1989; S. Sausage-Rumbough 1986, and elsewhere) Primates have complex social lives determined by their place in the hierarchy of the social group.

Thus, modern non-human primates display highly complex behaviours indicative of cognitive flexibility and elevated cognitive capacities for learning.

Given the pattern of co-occurrence between climatic instability and evolution of ever increasing cognitive complexity in many species, but most noticeably in primates, one is prompted to interpret this correlation as more than a mere coincidence.

Thus, the hominid lineage responded to the erratic climatic fluctuations with increase in brain size and cognitive flexibility demonstrated in the record by the appearance of the first tools, at about 2,5 mya and much more elaborate ones by 1.5 mya.(Williams, B.,2016). Given that cognitive flexibility as adaptation to environmental changes is to be expected as a general tendency in evolution , one can extrapolate that humans are far from unique in their adaptive response to change by evolving elevated cognitive and behavioural complexity. In this context humans can be regarded not as an exception but just an extreme case of a general trajectory of adaptation by learning as a response to alterations in the environment.

2. CLIMATE INSTABILITY AND HUMAN SPECIATION

Climate has been a significant factor in the evolution of life forms and human speciation is not an exception. Given the biological, cognitive and behavioural continuity of life forms , one can anticipate that the same factors influencing the evolution of life forms in general have influenced human evolution as well. Moreover, climate has been a major transformational factor in the formation and transformation of human societies in recent human history. Climatic fluctuations were found to be the defining factor in the rise and fall of human civilizations from the Arctic hunter-gatherers to the Mayan civilization. (J. Diamond, 1997; P.Richerson, R. Battinger, R. Boyd, 2005) . Given that climate has influenced pre-human evolution as well as more recent stages of human history, one can infer that it also has shaped humanity in early stages of speciation.

2.1. Human evolution and the evolution of the flexible brain

Behavioural complexity corresponds to complexity of brain architecture. Experimental evidence from brain studies shows that complex behaviours are not concentrated in one location as locally organized connections usually process specific, usually perceptual information. Instead, complex behaviours are distributed among spatially separated but interconnected areas of the brain, each area responsible for processing a certain aspect of the complex behaviour. The interconnected areas, each forming neuroanatomical structures, constitute circuits.

Language processing is one of the complex behaviours, another being mathematical ability, ambition, etc. Ph. Liebermann (2002, p. 38-39) shows that the neuroanatomical basis for language processing is the circuit composed of the interconnected Broca's and Wernicke's areas, areas adjacent to these, as well as homologous areas in the right hemisphere, in addition to the motor cortex and prefrontal cortex (Ph. Liebermann, 2002, p.50). Similarly studies have found that the localization of language in the brain is difficult to pinpoint given that a large portion of the brain is involved in one way or another in language-relevant functions, including subcortical regions such as striatum, cerebellum, thalamus, among various others. (S. Fisher, G. Marcus, 2006). Moreover, in language processing syntactic computations involving long distance dependencies among structural positions in grammar are not concentrated in any one location but involve coordination of a network of neurons located in various parts of the brain (E. Kaan, 2009). Importantly, the young brain displays flexibility in the formation of language-relevant neuronal circuits which makes possible to compensate for damages as demonstrated by recoveries from injuries (A. Fedor, et al, 2009)

Thus, language is represented in the brain as a complex network of neuronal connections widely distributed throughout about half of the brain, and include Broca's and Wernicke's regions among various others. In fact the bio-cognitive representation of language, i.e the Language Faculty, is said to be "the most invasive" i.e. the most widely distributed cognitive faculty in the human brain. (B. Gulyas, 2009, p. 59)

Similarly, T. Deacon (1997) advocates for a holistic approach in understanding the functions of the brain in complex cognitive behaviours.

"The central problem faced by the researchers studying the brain and language in that even the minutest divisions of cognitive functions we hope to explain at the psychological level are ultimately products of the functions of the whole brain... If there was ever a structure for which it makes sense to argue that the function of the whole is not the sum of the functions of its parts the brain is that structure." (T. Deacon, *ibid*, p. 287).

Thus, behavioural and cognitive complexity is made possible by complex brain organization. From evolutionary perspective a co-dependence is detected between the evolution of flexible brain and complex cognitive functions in humans.

2.2. Innovation as adaptation

Humans are not a new type of life form, although we are unusual species in more than one way. That said, it has been difficult to pinpoint what exactly is what makes us different as

Recent studies have shown that all traits which initially were thought to be exclusive to humans and explain the purported human uniqueness, are found in non-human species, albeit to a various lesser degrees, e.g. upright walking, large brains and general intelligence (M. Donald, 1993), recursive thought (M. Corballis, 2011), sociality and altruism (M. Tomasello 2008 and elsewhere), capacity for learning and using simple language-like communication (S. Savage-Rumbaugh, 1986 and elsewhere), tool-making and use, complex social organization (T. Fitch, 2010), etc.

Currently, syntactic language is viewed almost unanimously, as the difference which makes the crucial difference, the hallmark of human uniqueness as species.

Alternatively it was argued that a human capacity for innovation is the most distinctive trait and the source of the human evolutionary success. Premack (in M. Donald, 1993, p.161) argues that “language should not necessarily be seen as *the* human adaptation. Consciousness, pedagogy, social attribution, and aesthetics are also uniquely human.” and that “language was part of the change, but not the whole part.” (Donald, *ibid*, p.161).

S.Kuhn and M. Stiner (in S. Mithen 1999) define innovation / creativity as variation in artifact forms which change rapidly and, once invented, usually by a single individual, are “widely adopted and retained over long periods” (*ibid*. p. 146). So, creativity is associated with finding diverse and multiple solutions for a problem in terms of technological innovation or in artistic expression is not driven by pragmatic demands of problem solving at all. Thus, creativity has no immediate survival benefit which makes it difficult to explain with standard Darwinian processes.

Nevertheless it provides unanticipated selective advantage in highly unusual circumstances, e.g. abrupt climatic fluctuations, as it provides its bearers with a variety of alternative solutions to problems which standard Darwinian processes cannot address.

Innovation comes naturally in humans, although I am not aware of any discovery of a gene or genes for innovation. Nevertheless, the fact that all humans are intuitively creative very early in life, speaks of the presence of some kind of innate predispositions for creative behaviour. The fact that humans vary in their creativity points at the eventual role of evolution as explanation for its presence. P.Corning (2003) opines that inventiveness/ creativity initially begun as behavioural adaptation and was subsequently selected and became integrated into the human genome.

“... the evolution of humankind involved an entrepreneurial process - a pattern of innovation, trial-and-error learning, selective retention and cultural transmission, and the subsequent natural selection of supportive anatomical changes.” (Corning P., 2003, p.198).

Creative behaviour is detected in early humans. S. Mithen (1999) points at “constant technological innovation”, “flexible innovative behaviour” as the crucial distinction between human and the Neanderthals. (*ibid*. p. 13). M. Donald (1993) has argued that capacity for innovation, demonstrated by the invention of symbols, is the major difference which defines the behaviour of early humans. He argues that flexibility of the human mind may be responsible for the invention of symbols, as a creative solution to information overload. (Donald, *ibid.*, p.136).

Importantly, an invention is not an accomplishment by a single individual: the recognition of the value of the innovation and its replication by the population is a component of the creative

process. The history of science knows many examples where an innovation of great value is not recognized and remains in manuscripts for centuries until it is dug out, understood and made use of many generations later. The inventions of Leonardo which were far ahead of his time and remained unused until centuries later come to mind. An invention by an individual dies if the society fails to become a partner in its dissemination and improvement. Thus, the author of an innovation is not the single individual but the group.

By contrast non-human species demonstrate little creativity and mostly fixed responses to environmental triggers. Modern apes and extinct homo species, despite undeniable cognitive sophistication, are known for highly restricted toolkit of rudimentary tools and little appetite for improvement. The Neanderthals, although have demonstrated some remarkable cognitive complexity, have shown little ability for innovation in the Acheulian culture. Donald speculates that limitations in the capacity to innovate explains their demise.

“The range of variation is small...Their culture appears invariant and stereotyped, compared with human culture, which seems infinitely variable in terms of play, custom, ...and expression. (M. Donald, 1993, p.126).

And further, “They were capable of using signs, but somehow the idea of inventing a signing system never occurred to them “ (S. Savage-Rumbaugh, in M. Donald, 1993, p.134).

So, non-human species have cognitive capacities comparable to ours, except for the ability to be flexible and creative. They can learn if they are taught, they can use what is already available, but they cannot invent novelties.

“Invention was, of course, the key piece of the puzzle....And invention is also a key aspect of human language capacity.”(M. Donald, 1993, p.134).

That said, the latest archaeological findings reveal that Neanderthals and Denisovans along with Sapiens survived and successfully exploited climatically diverse habitats and demonstrated a life style very similar to that of our ancestors', e.g. produced and used stone tools, clothing and footwear. Evidence of burials, diverse diet, use of medicinal herbs was also found, suggesting advanced cognitive abilities and complex social relations. Moreover, Sapiens, Neanderthal and Denisovans co-existed, shared territory and interacted in Eurasia, Levant, Siberia for more than 50,000 years. (D.Dediu, S. Levinson 2018).Genetic studies reveal traces of Neanderthal and Denisovan genomes in modern human populations, evidence for interbreeding, suggesting intermarriages and resulting from that intertwined histories and cultural traditions. Similarities in anatomy, patterns of infant and child development, although significant enough to justify the conceptualization of these three branches of Homo as different species, nevertheless, appear smaller than previously thought. It is natural to expect that intelligent beings, biologically, cognitively and culturally compatible, would have some form of shared communication, including some form of language, quite possibly, of comparable complexity to human language, especially given the latest findings (A. Barney et al. 2012) of articulatory capacities comparable to the sapient, suggesting the cognitive ability to memorize and process a large vocabulary.

Despite all similarities all non-human homo species are now extinct and Sapiens is the only surviving one. And although extinctions of intelligent beings can result from a combination of multiple factors, most likely diseases and/or, as recent human history suggests, war and genocide, insufficient ability to cope with high-amplitude environmental changes due to

insufficient cognitive flexibility and capacities for innovation as a significant cause for extinction is more likely than not.

Creativity is rare in life forms and there is a reason for that : the creative process is very energy consuming activity and for this reason is avoided when possible. The brain processes consume a significant portion of the energy the body produces, estimated at close to 1/3. It is reasonable to expect that creative thinking takes up a big part of it, although characterization of the energy cost of creativity in exact numbers is probably difficult. In this sense it is plausible to expect that Neanderthal bodies could not afford such high energy expense. This is why perpetual creativity of all humans is not a realistic expectation. Truly creative individuals are so few and are very highly appreciated and celebrated members of the society. The same principle applies to linguistic creativity. Although all humans are born with the capacity to be creative and one of its applications is in linguistic communication , it is a fact that a large percentage of the phrases we utter are recycled/reused from previous and recent linguistic experiences , spoken or heard, as this puts less pressure on the memory and saves brain energy. Creativity is also limited by learning constraints. Only products of creativity which are easily learned are passed on. In this sense, in compensation for the natural limitations to the creative powers of the human brain , humans, as social animals, in addition to highly flexible infant and children's brains, have evolved extended learning opportunities, i.e. a period of adolescence, allowing for effective proliferation of the results of others' creativity.

Moreover, humans have discovered that reference to past behaviour and its reuse in new ways may stimulate innovation by repurposing, reshaping, adjusting old experiences in new contexts. History shows that accumulation of past knowledge and its creative reuse is the corner stone of human culture and civilization.

Language is the most obvious tool for encoding preserving and transmitting available knowledge and experience in order to facilitate future innovation. This suggests that not language per se, but the ability to creatively adapt old experience for solving new problems is the proverbial Rubicon no non-human species have been able to cross.

Although this timing sequence could be viewed as accidental, the assumption of causal connection between climate instability and the unusually elevated human cognitive capacities is justifiable for the following reasons:

- a. There is a good fit between the demands of the environment and the adaptations in response to these demands, thus, environmental unpredictability precludes the possibility of biological adaptation by standard Darwinian processes as gradual and time-demanding and stimulates behavioural and cognitive adaptations geared to fast learning and innovative problem solving.
- b. Evolution of elevated learning capacities and encephalization as an adaptive response to environmental instability, is not unique to humans, thus, can be attributed to a general tendency in evolution, not as an exception. Perhaps what is uniquely human and unusual is that it is taken to an extreme in human species.
- c. The fact that humans are the only surviving homo species , while Neanderthals, Denisovans and , probably other homo subspecies, known to have limited capacities for innovation , in environment demanding innovation, are extinct, suggests a causal connection between these two facts, rather than mere coincidence.
- d. A unique response to the same environmental demands is what differentiates species form

one another, i.e. uniqueness is not unique. The uniqueness of human species is the capacity for innovation.

In short, a speculation of causality between climatic instability and the evolution of human ability to innovate, in my mind, is not a post hoc -propter hoc fallacy but a logical deduction founded on well known facts and their reasonable interpretation.

2.3. Capacity for innovation and the brain

Any cognitive ability must be reflected in the architecture of the brain. In most cases an innovation does not start from zero, but relies on accumulation of past experiences which are creatively reused and repurposed. The ability to produce innovations is conditioned on two capacities, which, although different in nature, are interconnected and coordinated for the creative process to take place. The ability to retain and accumulate past knowledge and experiences and the capacity for its efficient recall and reuse are spatially separated in each hemisphere and can be theoretically defined as dichotomy of novelty vs. routinization. E. Goldberg et al. (1994) find that the right hemisphere is specialized for processing new experiences, while the left is specialized for processing routines.

“... the right hemisphere is critical for the exploratory processing of novel cognitive situations to which none of the codes or strategies preexisting in the individual's cognitive repertoire readily applies. The left hemisphere is critical for processing based on preexisting representations and routinized cognitive strategies.” (ibid. p. 372).

And further “The left frontal systems appear to be crucial for cognitive selection driven by the content of the working memory and for context-dependent behaviour, the right frontal systems appear to be crucial for cognitive selection driven by the external environment and for context-independent behaviour. The role of the right hemisphere in processing cognitive novelty highlights the importance of the right frontal systems in task orientation and the assembly of novel cognitive strategies.” (ibid. p. 375).

So, if I understand it adequately, the brain's evaluation of novel experiences and their incorporation into new behavioural and cognitive routines is the result of cooperation between the frontal lobes in each hemisphere.

This brain organization is by no means specific to humans and is found in all animals capable of learning. That said, the frontal cortex in humans is the largest proportion of the brain compared to non-human species. E. Goldberg (2001) views the correlation between the enlargement of the human prefrontal cortex, which in humans is 29% of the brain, as compared to 7% in dogs and 3.5% in cats, and speculates that the evolution of our species as a “runaway of the brain” where the processing of novelties runs into a spiral: the brain produces novelties in the right hemisphere, learns and compiles these as patterns/routinizes them in the left hemisphere which feed into and stimulate the next cycle of innovation as these are reimagined and reinterpreted in the right hemisphere. This means that products of innovation are a result of both imagination and prior knowledge and experience. Some of these are assembled by recombination of some aspects of previous experience, e.g. creatures found in legends, like mermaids, the Minotaur, etc., others have a lesser dose of reality, e.g. digitalization of knowledge. So, innovation is rationalized imagination, produced by the interaction of the

two hemispheres.

Thus, the association of the two hemispheres and especially the unusually large prefrontal areas of the cortex are the location of the human capacity for innovation and the cognitive and behavioural foundation of humanity and civilization.

2.4. Biology -learning co-evolution as body's adaptation to change

Retention and routinization of new experiences through biology-learning co-evolution is a natural process detected in many species as a defensive strategy in coping with environmental challenges is an important aspect of evolution as a multidimensional process (E. Jablonka, M. Lamb 2005)

“...natural selection can convert what was originally a learned response to the environment into behaviour that is innate.” (Jablonka, Lamb, 2005, p.285).

Waddington's experiments with *Drosophila* (Waddington 1953) demonstrate “genetic assimilation of acquired characteristics”, or behavioural alterations, initially achieved by learning will, with time, become incorporated in biological development of the offsprings.

Baldwin argues that a behaviour, which initially consumes much effort and time to learn, can gradually become easier to master with every new generation to the point when very little or no learning is required and the behaviour essentially becomes instinctive, known as Baldwin effect.

Human evolution provides ample examples of biology-culture co-adaptation, eg. lactose tolerance in humans as adaptation to domestication of animals and farming. Another example is the sickle cell anemia, an adaptation of the human organism to malaria as unintended result from burning of vegetation for farming, resulting in the formation of reservoirs of still water where mosquitoes abound and spread malaria.

Lumsden and Wilson (1981) argue that the genome provides for some flexibility in the form of genetic underspecification at birth leaving the environment through epigenesis to fill in the gaps and allow certain behaviours among a limited range of genetically underspecified options to be selectively developed at the expense of others. On evolutionary time scale the human brain and culture shape each other and that the relationship between genes and culture is one of cycles of mutual adjustments, a process termed “coevolutionary circuit” “from physical time and cultural evolution, to cultural time and genetic evolution, and back again.” (Ch. Lumsden, E. Wilson, 1981, p. 237).

Interaction of biology and culture is also demonstrated in the mutual adaptation between the brain and writing. S. Dehaene and L. Cohen (2007) found that the brain of a normal human literate adult has a dedicated area for processing orthographic symbols, allocated in the area of the cortex evolved to processes visual information. Its location and shape are invariant across cultures. The human abilities for processing orthographic shapes and the primate's visual capacities for object and scene recognition have shown similarities, suggesting evolutionary continuity. Moreover, the authors argue that the shapes of the letters in alphabets display universal features, e.g. the letters are composed of three strokes on average (Y, N) which intersect in specific ways. And although the study seems to be limited to individuals familiar with the Roman alphabet, the claim that the world's writing systems have been

designed to fit the innate biases of the primate visual system, which limits cultural variation, seems valid.

In sum, human biology has responded to the demands for dissemination of knowledge as culture has adapted to the limitations of the biological organism. It is reasonable to suppose that accumulation and preservation of previous knowledge and experience through proliferation of writing is advantageous to human civilization as source and stimulation of innovation. Adaptation of biology to elevated demands for learning is also reflected in human development by evolving a unique developmental schedule. Humans are 98% genetically similar to primates but they are behaviourally very different. This suggests that the evolution of the human species has been largely extra-genetic. The period immediately after birth is a period of physical and cognitive development, including learning in many species. In humans the period of development is much extended, i.e. it lasts about two decades and includes adolescence, unique to our species, a period of guided practice, a type of apprenticeship of how to be a productive member. It is an evolutionary adaptation to living in highly complex environment which requires extensive learning and practice of various skills.

Learning in humans is predominantly through social interaction as humans learn from interactions with conspecifics, i.e. social learning. Much learning is accomplished by imitation. And although some animal species have demonstrated some level of social learning, e.g. some rat colonies (P. Richerson, R. Bettinger, R. Boyd 2005, p. 231), social learning in humans is much more broad, fast and accurate. Imitation in humans begins in early childhood and continues through life.

A primary avenue for learning is communication through language. Evolution has prepared the human organism for fast and efficient learning of key aspects of language as innate predispositions for learning a basic lexicon of constructions, abilities for ostensive communication as a type of theory of mind, infant babbling period as the developmental onset of the capacity for speech, incorporated in a Language Faculty. And although the bio-cognitive details of the Language Capacity are a matter of debate, its existence is largely undisputed.

In sum, humans have discovered the advantages of accumulation of knowledge and its preservation by learning as a response to environmental unpredictability caused by violent climatic fluctuations. In addition, our ancestors have discovered the value of innovation and its proliferation as the species' unique and highly effective defence against unexpected environmental challenges by creating variation of alternative solutions as sources of selection opportunities. In unpredictable environments innovation is adaptive.

The human organism has responded by adapting genetic, epigenetic, developmental flexibility in the body and mind in support and stimulation of learning in service of invention and routinization of novelties.

2.5. Complex civilization, unintended consequence of adaptation to erratic climate fluctuations

The extreme climate instability dissipated at about 11,000 years ago (ya), marking the beginning of Holocene, a period of climate stabilization (Richerson, Bettinger Boyd, 2005). Soon after that the beginning of human settlements, agriculture, and subsequently, writing

and the onset of the first civilizations are detected. This invites a plausible speculation that the above listed adaptations of the human body and most notably the brain and mind, and especially of capacities for innovation, initially having evolved as adaptation to violent and unpredictable climatic alterations for purely biological survival, after the stabilization of the climate on earth during the Holocene were not needed for survival advantage any longer. In other words, humans ended up with extra capacities demanding a lot of energy to maintain and which the biological body cannot afford to waste.

That said, evolutionary biology provides extensive evidence for increased cognitive complexity as adaptation, but, to my knowledge no evidence of excessive intelligence as detriment to survival, resulting in its reduction. In this sense, one can plausibly speculate that the elevated human cognitive capacities, which in the new and more favourable environments were exceeding the demands for basics of survival, were deployed for the development of civilization and complex culture. Intelligence is difficult to evolve and no life form can afford to waste it.

2.5.1. Innovation and self-domestication

Self-domestication is a key aspect of human evolution defined in terms of genetic metabolic, behavioural adaptation of our ancestors to self-imposed living in permanent settlements, geared at taming the natural urges for physical aggression and replacing these with emotional self-control (Shilton, Breski, Dor Jablonka, 2020) or verbal aggression (Benitez-Burraco, Progovac, 2020). In other words, self-domestication is the formation of a new niche as adaptation to fellow minds and associated with that development of new means of communication, including modern language. (Benitez-Burraco, Kempe, 2018 ; Benitez-Burraco, Progovac, 2020).

This article attributes this adaptation to climatic instability during a prolonged period of about 2 my. The last glacial period ended at about 11,500 ya and was followed by Holocene and the end of climatic instability. It coincides with the beginnings of civilization, demonstrated by the appearance of settlements, farming, domestication of animals. And although the temporal overlap between these two phenomena can, on the surface, be taken as a mere coincidence, given the evidence provided above and the logical conclusions extrapolated from it, a more plausible explanation points at a causal dependence between the two. Such explanation can be articulated in a hypothesis that cognitive capacities for innovation, initially evolved to meet the challenges of nature, after these challenges eased off, were deployed in creating a new environment. In this sense the cognitive potential for innovation, initially evolved as adaptation to environmental challenges, unleashed cognitive power for goals other than simply biological survival and deployed it for tackling the challenges imposed by settled communal living, marked by stability and predictability of daily existence. Similar change in behaviour is noticed in animals domesticated by humans, e.g. dogs and horses, for which the struggle for finding food and protection from predators is eliminated in domesticated conditions, allowing to deploy their cognitive potential for pleasing their human owners by learning to follow commands and perform jobs.

The new, invented environment took different forms in different communities which resulted

in the emergence of cultural diversity. Culture is defined “ ... as the existence of intra-species group differences in behavioural patterns and repertoires , which are not directly determined by ecological circumstances (such as the availability of particular resources employed in the differing behavioural repertoires) and which are learned and transmitted across generations.” (R. Singha, 2009, p.294). Thus, culture is understood as development of artifacts and behaviours not necessary for survival. And although cultural traditions must reflect and incorporate aspects of the local bio-physical conditions, the fact that wide cultural diversity, including linguistic diversity, exists in the same environment suggests that culture and natural environment are only indirectly related. Moreover, humans invented a new reality of social institutions, e.g. money, government, marriage, property, etc. (J.Searle, 1995). In short, the unique response to environmental challenges of humans fostered the emergence of human civilization.

Importantly, it is reasonable to speculate that , given that various homo branches very similar to sapiens genetically, developmentally, behaviourally, socially, communicatively, co-existed and even interbred with sapiens for extensive periods , were deficient in their capacity for innovation, it is reasonable to speculate that it is this deficiency, which constituted a major impediment in their ability to cope with unpredictability of climatic change and which likely was a significant contributor to their extinction.

To recap, the unusual characteristics of the humans species is their ability to be spontaneously creative. This is a cognitive ability universally present in all humans. It is also the underlying common denominator under all unique human behaviours including language and all aspects of culture.

3. THE ORIGIN OF LANGUAGE AS A TOOL FOR DISSEMINATING AND PERPETUATING INNOVATION

3.1. Language as depository of knowledge

Ever since Saussure linguistic forms are defined by its symbolic nature, i.e. linguistic forms are symbols. And although linguistic paradigms diverge in their understanding of what language is, e.g. a lexicon of constructions as accidental associations of form and meaning in the usage-based approach, or an algorithm, thus, by definition a program for manipulation of symbols, in the generative approach, both dominant perspectives, implicitly or explicitly, converge on the assertion that language is a system of symbols.

Symbols are a type of signs and signs, by definition exist only for the purpose of communication. The only reason to attach a label to a concept and form a sign is to communicate something to a receiver, i.e. someone other than the sender. Thus, a system of symbols is by definition a system for communication. The reason for attempting to communicate by sending a message is to communicate something, i.e. to share some information. Communication, by definition, implies meaning.

Language is usually defined as symbols and structure, i.e., a lexicon and grammatical rules by which items from the lexicon are combined into larger units. And although in the generative approach the focus is on structure, grammatical rules exist only for the purpose of efficiency of

meaning representation. In sum, meaning is the sine qua non of language, there is no language without meaning. This is why the most famous sentence in modern linguistics “Collarless green ideas sleep furiously”, aiming to illustrate the dominance of structure over meaning, is not language. Linguistic meanings reflect human conceptualization of the world, i.e. human knowledge and experience with the world. Given that, language is better understood when defined as depository of knowledge and experience, or a library of knowledge.

Language encodes information about:

- * the material reality from anthropocentric perspective : topography, flora and fauna, climate, including human perspective of size, distance, speed, time,
- * human body and mind: body parts, internal organs, cognitive processes, physical activities,
- * artifacts : housing, clothing, life style, nutrition,
- * culture: religion, cultural beliefs and activities, cultural values,
- * civilization : agriculture, science, philosophy,
- * social organization : types of social organization and social institutions

The linguistic representations of these meanings include all types of linguistic forms, all types of lexical and grammatical categories.

Naturally, concepts of basic aspects of the environment, e.g., geography, flora, fauna, basic human biology, psychology and sociology, thus, concepts pertinent to essential survival and functioning of humans as biological and social beings are universally encoded in all languages. Cultural aspects of the semiosphere are idiosyncratic (A. Wierzbicka 1992; C. Goddard, 2007, and elsewhere). Moreover, T. Schoenemann (1999, 2005) argues that the structured organization of the extralinguistic reality as conceptualized by the human mind is reflected in the organization of language. J. Haiman (1983); R. Langacker, (2008); V. Evans, M. Green (2006) argue for the motivated nature of the meaning- form correspondence in linguistic structure and specifically the iconic and isomorphic nature of this correspondence.

M. Haspelmath (2008) argues that the structure of experience, reflected in conceptual structure, influences the shape of grammar.

Some types of iconic mappings of meaning and linguistic form are:

- a. iconicity of quantity: Greater quantity is represented by a proportionately greater number of linguistic forms, for example, the singular form of a noun is shorter than the plural as in book/books, reflecting the correspondence in quantity of the referents.
 - b. iconicity of complexity : More complex meanings are encoded in proportionately more complex linguistic forms. For example causatives are semantically more complex than non-causative. As an illustration, the semantics of KILL is more complex than that of CAUSE TO DIE and this is reflected in the greater complexity of the linguistic form which encodes it.
 - c. iconicity of cohesion: The conceptual distance between expressions corresponds to spatial distance between their linguistic forms. For example the conceptual distance of a verb and its object in transitive constructions is reflected in the spatial closeness of the two in the linear order of the sentence. In the same vein the spatial closeness of the possessor and possession is understood. Similarly the relation of coordination in meanings mirrors their expression in forms (in J. Haiman, 1983, p. 783). Cognitive linguistics (V. Evans, M. Green, 2006) sees linguistic meaning as a reflection of perceptual experience.
-

“...semantic knowledge is grounded in human interaction with others (social experience) and with the world around us (physical experience).” (Evans, Green, *ibid.*p.243) .

In addition, language contains knowledge about itself. As internally organized and highly integrated system it displays continuity in the semantics of linguistic items along a continuum from content nouns to forms with increasingly more abstract meanings, i.e. prepositions, tense/aspect/mode markers, definite/indefinite articles, etc . Thus, language is organized along a continuum of meanings (A. Goldberg, 2003).

Moreover, language contains information about language use, e.g. pronouns are used to avoid repetition , definite/indefinite articles inform how the information is structured, e.g. old vs. new. The presence of synonyms and antonyms in all types of linguistic entities is along the semantic continuum and also demonstrates the structural integration of the system as a whole. Importantly, creative reinterpretation of literal linguistic meanings in metaphors, irony, double entendre, etc.makes possible the use of language as art form.

In sum, language itself is a source of information as it is a rich depository of knowledge about aspects of material reality important to biological survival through people's experiences with it , aspects of social reality in which communities interact and conduct their daily lives, knowledge about language as an internally organized system and the principles of its use in communicative interactions.

Thus, it is not possible to learn a human language without learning about the human species and it is not possible to learn a foreign language without learning about the community of its speakers.

4. LANGUAGE ORIGINS AS EVOLUTION OF SEMANTICS

Language is a complex and heterogeneous phenomenon. Its use and learning involves the participation of human biology, development, cognition, socio-cultural context of use. Given this heterogeneous nature of language , its evolution is rightfully defined as a complex array of evolutionary processes interacting in various contexts and time scales (Jablonka, Lamb, 2005) Given that, it is logical to suppose that different aspects of the co-evolutionary process have influenced differently or to different degrees the formation of the components of the language complex. Alternative linguistic perspectives focus on some of these components at the expense of others.

On the one hand, language is defined as syntax and its existence is explained in terms of biological evolution in the internal reconfiguration of the human brain which a Language capacity, or a bioprogram containing highly abstract syntactic rules, has appeared overlaid upon pre-existing capacity for meaning-based lexical protolanguage (Chomsky,1980, 1986, 1988; Bickerton ,1990, 1984 and elsewhere). In this context the evolution of language is understood as imposing additional structural constraints on pre-existing meaning-based configurations of lexical words, i.e. the evolution of language is evolution of structure, not meaning.

On the other, language is defined as a list of constructions of various sizes and types, i.e. pairings of form and meaning, which suggests that meaning can be encapsulated in forms of all

types of linguistic forms along the continuum of lexical words and grammatical forms (Goldberg, A.2003). In this context the origin of language is understood as semantic expression of basic meanings and further evolution of language, as a process of extending the semantic representation of semiosis in various types of linguistic forms.

In the generative tradition as per Bickerton (1984 and elsewhere) a meaning-based lexical protolanguage is attributed to pre-human species, suggesting that humans have adopted the conceptualization of reality from non-human minds, during their co-existence and interaction during millennia. This contradicts the fact, well known by cognitive science, that concepts are species-specific. And although pre-human ancestral species are known to have had bodies, brains and minds largely similar to ours, it is also known that human brains and minds are organized differently, suggesting that so are human concepts. A human language can only be used and learned by human minds.

From a different, but related angle, the lexicon, as a compilation of constructions, is also uniquely human trait as humans remain the only extant species to spontaneously invent and memorize constructions with ease. Although some members of non-human species have demonstrated abilities to copy and use some lexical words with concrete meanings under highly atypical circumstances , at present no non-human animals have invented a lexicon of any size . At present evolutionary time word invention remains uniquely human ability.

4.1. The formation of common semiosis as the beginning of language

In most species concepts are innate and, thus, belong to the individual mind, even in highly social species, e.g. bees. In contrast, human concepts are formed by convergence on common perception of reality through social agreement, a process preceding the formation of common semiosis, i.e. the process of signification or formation of meaning and signs.

The origin of language as a meaning-based system begins with formation of common ground, i.e. convergence among all members of a group on common conceptualization of reality, beliefs, world views. In a closed group of interacting individuals the members are united by common daily experiences. Eventually these become routinized and common patterns of behaviour emerge and become recognizable. They become behavioural common ground, i.e. group members are expected to behave in certain predictable ways. It is plausible to suspect that the formation of common habits was one of the prerequisites and a stepping stone for the origination of language as common habits lead to the formation of common meanings, an essential component of signs.

The uniquely human propensity for cooperation has resulted in the formation of common ground as potential meanings, a sine qua non of any type of communication. It is paramount for the formation of the lexicon of constructions as stable meaning-form pairings. Moreover, behavioural common ground reflects the structured nature of experience and becomes a prerequisite for the formation of semantic structure and, subsequently, the structured association of abstract categories, i.e. grammar.

It is expected that the most primitive concepts are most likely to be encoded in the first lexicons. Heine and Kuteva (2007) demonstrate through reverse engineering by examining the

histories of multiple languages that the lexical categories first to emerge are nouns and verbs with concrete meanings.

4.2. Speculations on the origin of the first lexicons

Inquiries into the origin of language are based on the premise that the circumstances which prompted the origin of language can be partially replicated today. And while the findings of these inquiries remain speculative, one can assume with high degree of confidence that early forms of language were simpler in reflection of the limited knowledge the first speakers had of their natural and social environment and the limited need for information transfer in these circumstances.

As direct evidence for the beginnings and earliest stages of language is unavailable, this challenge is addressed by applying modern technological advances, specifically in artificial intelligence, to partially recreate and mimic the original conditions of the beginnings of language. L. Steels '(1995) experiments with robots demonstrate that it is possible for individuals with divergent mapping +form mappings, after repeated interactions to converge on a shared vocabulary of predominantly lexical words.

Lexical words with concrete meanings are also the first to emerge in new languages(Sandler, W. et al, 2005) and home signs (S. Goldin-Meadow 2002). These are treated as windows into language evolution under the assumption that the process of lexical word formation marks the beginning of human language. This also suggests spontaneous, instinct-like, urge for coining words as innate predisposition for communicative innovation as a part of a broader human capacity for innovation.

In comparison linguistically trained apes have demonstrated limited ability to learn human words, compared to human children. And although they have demonstrated some creativity in communicating with words, limitations to learning in general suggests also limitation in creativity.

4.3. Semantic categories, nature and nurture

Meaning is the species-specific way in which the external world is reflected in concepts by patterns of brain activity. Concepts reflect the cognitive capacities of the species. Thus, concepts are species-specific.

Linguistic meaning, or semantics is the interface between thought and language. Linguistic semantics is formed as selected parts of the semiosis are focused upon and elaborated by imposing additional structural organization in terms of Theta roles for the purpose of being represented in linguistic forms. Semantics, arguably, the most central aspect of language, ironically, is understudied and underdeveloped in modern linguistic theorizing. The generative approach understands linguistic meaning in terms of principles of computation as stable, timeless and objective i.e. disembodied, thus, independent of reality and human experience, meaning primitives organized into fixed semantic categories the most basic of which are agent, object, action, location, property, etc., under the Language Of Thought hypothesis (LOT)(Fodor, J. 1975). The meaning of a sentence is computed when the semantic

primitives combine by predetermined rules and form hierarchically organized semantic structures. In this context both the semantic categories and the hierarchical structures are understood as abstract, universal and independent of experience with reality. The interpretation of linguistic meanings is defined as correct if it is in accordance with strict rules of interpretation, borrowed from logic. The use of semantic structures in communication as a statement of some fact in reality is defined in binary features as either true or false. The conditions under which the statement expressed by the sentence is true corresponds to some fact of extralinguistic reality.

In this context human concepts are innate, i.e. predetermined, and eternal, as the LOT is a set of all possible concepts human mind will ever need to know, a vision of the human mind adopted from Descartes and his “innate ideas”.

Such understanding of human cognition has profound and broad consequences, theoretical and practical. For philosophy of knowledge if all concepts are innate, it follows that humans do not acquire new knowledge. Thus, a new discovery in science or a technological invention is not new at all and creativity is reduced to realization, awareness of something we instinctively know from birth. The LOT hypothesis has also consequences for language acquisition: if meanings, and the rules to combine them, are innately given, then what is learned is only their phonological labels. There are also consequences for the theory of translation. If all humans have the same concepts there should be no mistakes in translation.

Thus, as both scientific theories and pragmatic knowledge demonstrates, the LOT hypothesis, as well as Descartes' vision of the human mind in terms of God-given or innately predetermined “innate ideas” reveal inadequate understanding of human cognition.

Moreover, the postulation of Logical form, the component of the Language Capacity where meaning is processed, relies on generalizations from the semantics of European languages and mistakenly taken as universal property, while not demonstrable by the semantics of most world languages.

“...the same fact or event is not only expressed differently, but also structured semantically in a different way, in different languages” (D. Zaefferer, 1991, p. 46).

As a counterargument scholars (L. Steels 1995, Ke, 2002) argue that semantic categories are emergent as a result of human experience. In this context semantic categories are arbitrary and idiosyncratic, not universal, given that communities differ in choices on which concepts to be linguistically encoded as well as choices of the type of constructions by which they are materialized. Thus, semantics is a product of self-organization and determined by the individual language in specific cultural circumstances.

That said, there must be a considerable overlap in semantic categories in the minds speakers of a sociolect as they share the same natural environment, the same cultural and social settings. Thus, although languages appear to conceptualize the world in different ways in reflection of cultural idiosyncrasies, there exist a common core of semantic universals, which makes translation generally possible.

In addition, semantic categories are formed by self-organization at the level of the idiolect and

vary from person to person, depending on people's experiences. That said, there must be a considerable overlap in the semantic categories in the minds of the individual speakers as they have the same bodies and brains, the same cognitive capacities and physiology and thus, have very similar experiences. This overlap among idiolects of a language makes communication possible.

Thus, despite demonstrable diversity, universal semantic categories are a fact of human language. This suggests that these are more likely to have some, perhaps epigenetic, foundations in the human organism, explicable in phylogenetic terms as a component of the Language Faculty.

4.4. Universal semantics and the Language Faculty

To reiterate, concepts of basic aspects of the environment, natural and social, e.g., geography, flora, fauna, basic human biology, psychology and sociology, thus, concepts pertinent to essential survival and functioning of the individual as a biological being and a member of a group, are universally encoded in all languages (A. Wierzbicka 1992; C. Goddard, 2007). And these are universally encoded in lexical words with concrete meanings. It is logical to anticipate that they form the very foundation of language. It is also logical to assume that the linguistic representation of these concepts marks the beginning of language, which prompts the expectation of some form of innate underpinnings facilitating the early attainment of these concepts in childhood. In fact P. Bloom (2000) argues that all children display some universal and specific preferences when learning their first lexicons irrespective of the grammatical properties of the language learned. They consistently pay attention to nouns as opposed to any other grammatical categories and as a result find nouns easier to learn than, say, verbs or adjectives, i.e. demonstrate nominal bias. Among nouns words for tangible objects are privileged. Thus, some concepts, essential for essential communicative functions are universally encoded in linguistic terms, predominantly in content words, predominantly nouns. The fact that innate cues for facilitating the early learning of these are detected early in language development suggests a role of phylogenesis.

Universal patterns of categorization are reflected also in the grammars of all languages: "...semantic categories which are reflected by grammatical complexities in natural languages belong to a very constrained subset of all the categories we use to think, feel and conceptualize the world" (in D. Dor, E. Jablonka, 2001, p. 39).

An example is the categorical distinction animate vs. inanimate objects, singularity vs. multiplicity, event vs. process, stasis vs. movement, etc. This suggests that the very essentials of human patterns of categorization, universally reflected in lexical and grammatical categories, which should reflect innate components of the Language Faculty and likely have become evolutionary targets given their obvious survival benefits.

Schoenemann (1999) argues that modern humans have evolved innate and therefore, universal, semantic categories as a unique aspect of human cognition by Baldwinian evolutionary processes where a cultural innovation becomes incorporated in human biology. In this context semantic categories, initially passed on by learning, with time gradually become

easier to learn with each successive generation. The final point of this process is when the learning required is either minimal or eliminated all together as they become reflected in human biology as innate bias facilitating their learning. In sum, nurture interacts with nature in facilitating the learning of some aspects of linguistic semantics, universally found to be essential to dissemination and preservation of essential knowledge over generations.

5. LANGUAGE EVOLUTION AS INCREASE IN SEMANTIC COMPLEXITY

The evolution of modern language from earlier, simpler forms is usually understood as imposition of grammatical rules on protolanguage, i.e. evolution of form. That said, B. Comrie and T. Kuteva (2005) have argued that concepts usually encoded in grammatical forms in modern languages almost always can alternatively be expressed in lexical words. Jackendoff and collaborators (P. Culicover, R. Jackendoff 2005; R. Jackendoff, E. Wittenberg, 2014) state that there is no dividing line between protolanguage and language as many fully functional languages spoken today, e.g. Piraha, Riau Indonesian and others display similarities to the putative lexical protolanguage by using minimal grammar. Given that, the difference between earlier, more primitive stages in language evolution and modern language is better understood as evolution of semantic complexity, i.e. as increase of concepts encoded in linguistic forms.

One way of expanding the number of lexical items is through metaphorical extension of pre-existing literal meanings of nouns and verbs (G. Lakoff, M. Johnson, 1980). J. Aitchison (1999) has shown that the names of human body parts are used to name newly discovered concepts for objects in the outside world and emotional and intellectual states and space vocabulary is extended to name time concepts. In short, meanings of words for concrete concepts are extended to name abstract concepts.

Expansion of the lexicon is also known to happen through the formation of new lexical categories.

ex. noun > adjective : orange (N) > orange (Adj) blouse ; silver (N) > silver (Adj) jewel

noun > adposition: front (N) > in front of (Adp); top (N) > on top of (Adp)

verb > adposition: concern (V) > concerning (Adp); regard (V) > regarding (Adp)

adjective > adverb: sincere (Adj) > sincerely (Adv); beautiful (Adj) > beautifully (Adv)

More examples can be found in Heine, B. Kuteva T. 2007.

Language evolution can also be understood as the emergence of new types of meanings from content word to highly abstract meanings on a cline

content word > grammatical word > clitic > inflectional affix, is articulated by the theory of grammaticalization (P. Hopper, E. Traugott. 2003; B. Heine, T. Kuteva, 2007).

T. Schoenenmann argues that the evolution of grammar can be explained as a consequence of increased semantic content, which triggers internal reorganization of the system by creating

multilevel hierarchical structures which are easier to remember, learn and process.

“...syntax grows out of semantics” (Schoenemann, 1999 p.311).

He argues that the hierarchical structure of sentences is a direct reflection of the way conceptual structure is organized and that phrase structures are groupings based on meaning relations (Schoenemann, 2005).

Thus, language evolution is, therefore, understood as evolution of semantic complexity, or the increase of the amount of concepts encapsulated in linguistic forms out of the totality of concepts humans are capable of conceiving. The process is termed “expansion of the expressive envelope” of language (D. Dor, E. Jablonka 2001), although I prefer the label “semanticization” as more descriptive.

It is natural to suppose this extended semanticization of the semiosis to be reflected in increase of the number of lexical words and the formation of additional new types of meanings encoded in fine-grained grammatical categories for the purposes of its more efficient communication.

5.1. Semantic complexity and language diversity

In linguistic literature modern language is usually defined in terms of complex grammar and, as per the generative perspective, in terms of syntax as a demonstration of human universal bio-cognitive properties.

That said, complex syntax is only one of various other alternative ways of encoding the rich semiosis, i.e. the grammatical system, envisioned by the generative perspective, is far from universal. To the contrary, M. Haspelmath (2007) and other typologists, have demonstrated that most grammatical categories are language-particular and grammar is where language diversity is most clearly demonstrated. This suggests that the function of grammar is largely a reflection of cultural diversity, rather than a bio-cognitive algorithm for encoding and processing universal meanings. Moreover, all languages have grammatical forms with no informative value with redundant functions e.g. gender marking on nouns for inanimate objects, repeated gender and number marking of the head noun on all participants in a NP in Romance and Slavic languages, double marking of negation in many languages. The emergence of modern grammar as highly complex hierarchical structures in syntax and excessively fine-grained morphology, then, could be explained as adaptation to a new function of language from assuring the basics of existence to marking group identity and belonging and reflects new attitudes of pride and patriotism. Thus, the emergence of complex grammar is beyond biology and speaks to the emergence of complex societies and civilization.

Language diversity is a result of the different ways communities organize their cumulative knowledge and encode it in linguistic forms. As per R. Keller (1994) languages as rule systems emerge spontaneously as unintended byproduct of the rational and intentional interactions of individual speakers to communicate with conspecifics in an attempt to solve interpersonal problems at a local level. Keller's “invisible hand hypothesis” argues for language formation as glossogenesis in rejection of any form of Language Capacity.

That said, studies referenced above strongly suggest some form of innate predispositions for learning of language essentials while the “invisible hand hypothesis” plausibly explains language diversity.

5.2. Bio-cognitive adaptations for extended semantics

Given the adaptive advantage of language as a depository of knowledge, primarily in lexical forms, various scholars have argued that evolution has favoured capacities for fast and effective learning of a large lexicon. Ph. Lieberman argues that components of the human brain most enlarged in comparison with the ape brain are areas used in word memorizing and recall. He shows that although apes can learn human words and successfully use them to communicate, the brain areas which underwent the biggest increase during human evolution are those facilitating word learning and use.

“...the almost three fold increase in the volume of these structures (prefrontal cortex and cerebellum) and the basal ganglia, compared to chimpanzees, could have yielded the computational base and memory size necessary to rapidly learn and store the meanings of new words... the posterior human brain, which current studies suggest is critical for accessing words from the lexicon ...is disproportionately large in humans compared to apes.”
(Liebermann, Ph. 2002, p. 52).

Thus, the human brain has evolved capacities for encoding and retaining extensive knowledge. In addition, language implies speech. And because, as per Saussure phonemic distinction is a marker of semantic distinction, extended speech capacities are suggestive of increased number of phonemes demanded by enlarged lexicon, which, in turn is suggestive of the semantic complexity of language. Thus, the species' linguistic and cognitive capacities can be estimated by the capacities for speech reflected in species' anatomy. For example, Neanderthals, although likely were language-capable species, their speech abilities were likely quite rudimentary as, as Liebermann finds, their articulatory organs were not capable of producing the so called quantal vowels /i,o,u /, uniquely attributed to the humans and attested in all languages. (Liebermann, Ph 2006, 2007 and elsewhere). Limitations of Neanderthal speech capacities, detected by Liebermann, point at limitations in the size of the lexicon and, by association limitations in conceptual complexity.

In sum, aspects of the human organism show adaptation favouring the formation and processing of a large vocabulary as a tool for preservation and dissemination of information and knowledge.

5.3. On diversity of languages and the bio-cognitive universality of human mind

Languages clearly differ in semantic complexity judging by the size of their lexicons as languages like English and Latin have large lexicons while some languages spoken in small and isolated communities have lexicons of only a few thousands.

That said, this does not imply in any way that the language speakers of one language differ in

their language-related cognitive abilities. The fact that one language has a larger lexicon than another does not imply that some speakers are more cognitively or linguistically advanced than others. This is because a large lexicon of constructions reflects the semantic complexity of the community as a whole. An individual speaker has only partial knowledge of the lexicon of one's native language. An English language dictionary contains about 500,000 entries and the average native speaker has a vocabulary of about 50,000 lexical items, or some 10%. Thus, no single individual, even one with the highest academic credentials, is even remotely close to ideal speaker. This is explicable with the inherent limitations of human memory. Moreover, an individual has an active lexicon, i.e., a number of lexical items most often brought to active use in communication, and a passive one, i.e., a much larger number of linguistic entities which, although recognizable and understandable when encountered in linguistic comprehension, are not likely to be used in linguistic production.

Moreover, languages of small communities only partly encode the semiotic universe of the group as members of a group are individuals with close social ties, i.e. “a society of intimates”(T. Givon, B. Malle 2004), who share significant part of knowledge and use mostly non-linguistic forms of communication, so there is no need for a large lexicon. Large and socially and ethnically diverse societies create information inequality which elevates the demand for explicit communication and encourages large vocabularies and grammatical details.

In sum, languages differ as depositories of communal knowledge, while individual minds are highly similar in their capacity to absorb and use this knowledge.

6. LANGUAGE AS A DEPOSITORY OF KNOWLEDGE IN SERVICE OF INNOVATION

Humans are labeled by anthropologists as the sapient species. Accumulation and preservation of knowledge is a defining trait of humans and human civilization is the result of it. This is made possible, in part by a capacity for social learning, i.e. the individual learns from interaction with conspecifics. In contrast, many species are capable of some form of individual learning from experience, which benefits the individual during its lifetime and dies with it. For example extensive accumulation of knowledge from personal experiences is demonstrated in chimpanzee individuals, which remain unrecorded and fail to benefit the species as a whole (Goodall, J. 1986 and elsewhere).

Social learning is one of the most defining behavioural predispositions of humans responsible for the evolutionary success of the human species. Through social learning the personal experiences and innovations of all individuals are combined, accumulated and improved over time. Individuals do not need to start from zero and rediscover the world through trial and error each time; they learn from the past experiences of others.

Humans have evolved genetic predispositions for social learning given its obvious adaptive advantages as accumulated knowledge is given for free.

“ With the ability to access accumulated knowledge, individuals can take advantage of a great store of information without having to take time and effort, metaphorically or actually, to

reinvent the wheel for themselves” (Alvard, M. 2003 p. 143)

Given the essential role of language in this process, it is natural to suspect that language was initially invented as a way of accumulating, preserving and sharing information about the circumstances of daily experiences in response to the demands for immediate problem solving and survival. With time the unintended result ended up being much far reaching as it makes possible the encoding and preservation of timeless knowledge and past experience while at the same time providing flexibility by introducing new linguistic items which disseminates new ideas and stimulates further innovation. The invention of language allows for stability of knowledge preservation and at the same time allows for newly uncovered knowledge as well as social and cultural changes to be encoded in new linguistic forms and creative reuse of existing ones. The introduction of more refined grammatical details is in itself an innovation as a way of making the system more efficient. (Benitez-Burraco, Kempe, 2018)

As acknowledgement of the need for further extending the knowledge dissemination cultures have invented new, even more reliable vehicles for preserving the ideas of past generations in the form of various semasiographic systems, i.e symbolic systems where signs are encoded in visual symbols, e.g. writing, musical notations, mathematical symbols, etc. were invented. Culturally transmitted information is cumulative as it is the accumulation of knowledge and its transmission in organized and condensed form. This is a unique aspect of human culture which makes it highly adaptive.

Human civilization developed by preserving, disseminating and improving the fruits of innovation. The result is a snowballing effect which has resulted in the development of great cultural and social complexity.

That said, language is different from other semasiographic systems in that humans have evolved some specific natural propensities for fast and effective learning of the basics of language, while writing, number systems and others must be learned from scratch with general cognition.

In sum, our ancestors invented language as a powerful tool for encoding, preserving and disseminating the accumulated knowledge and experience of past generations in order to facilitate and stimulate its future creative use. Given its adaptive value some aspects of language as learned human behaviour were permanently engraved in the human organism by mechanisms of biology /cognition -culture co-evolution.

SUMMARY AND CONCLUSIONS

Adaptation to the current environment is the fundamental principle of evolution. Climate is the cornerstone in the formation of this environment. Climatic instability in the last few millennia has driven the evolution of elevated intelligence as adaptation. This general tendency in evolution has become the focus of evolutionary change in the homo branch of primates as species with higher intelligence by evolving larger and more complex brains with extensive learning capacities. It has culminated in the evolution of homo sapiens by the evolution of highly elevated capacity for learning, creative problem solving and innovation. Humans have creative minds made possible by flexible brains as a universal property of the species. Various

experts in human cognition have pointed out, although not argued in sufficient detail, that what makes us unusual among life forms is an innate and exclusively human instinct to innovate. The evolution of culture and language is the clearest demonstration of these capacities. The invention of language as a depository of knowledge and a tool for preservation of past experience, was both the result of human propensity for innovation and a prerequisite and stimulus to future innovation.

In short, humans are unusual among life forms on earth in our innate propensity not only to respond to environmental changes by adapting to them post factum, but to actively change reality by innovation. We are inventors by nature and we carve our own islands of artificial reality amidst the harsh reality of brute nature by sharing ideas. The human organism is internally organized to facilitate innovation and human culture has evolved practices to stimulate it. The evolutionary success of the human species is a result of this unique trait. Although apes have shown clear ability to learn behaviours and words invented by humans, they have shown no capacity for innovation neither in terms of communication nor in everyday problem solving. Innovation is the most crucial difference which makes the difference between us and non-human species and it explains the gap in both general intelligence and communication.

The propensity for innovation is not well understood by cognitive science and is currently not at the centre of interest as its role in the evolutionary success of our species is underestimated. One of the goals of this article is to encourage further research of this topic.

Importantly, human communities use this innate potential for innovation to different extent. We witness highly complex societies, driven by aspirations to conquer other planets, co-existing with communities where life has hardly changed in thousands of years. Thus, members of the same species use their innate potential in remarkably different ways with remarkably different outcomes. Given the influence of climate in the evolution of human creativity, as the article argues, it would be interesting to explore if regional climate can be an explanation for these differences.

REFERENCES

Alvard, M. 2003, The adaptive nature of culture, *Evolutionary Anthropology*, 12, p.136-149

Barney A. et al. 2012, Articulatory capacity of Neanderthals a very recent and human-like fossil hominid, *Philosophical Transactions of the Royal Society B Biological Sciences*, Jan. 12 367 (1585) p. 88-102
doi: 10.1098/rstb.2011.0259

Benitez-Burraco, A., Kempe, V., 2018, The emergence of modern languages: has human self-domestication optimized language transmission?, *Frontiers in Psychology*, vol.9, art.551
doi: 10.3389/fpsyq.2018.00551

Benitez-Burraco, A., Progovac, L. 2020, A four-stage model for language evolution under the effects of self-domestication, *Language and Communication*, 73, p. 1-17

Bickerton, D. 1984, The Language Bioprogram Hypothesis, Behaviour and Brain Sciences (BBS) 7 p.173-221

Bickerton D. 1990. Language and Species, University of Chicago Press

Bickerton, D. 2003, Symbol and structure, a comprehensive framework for language evolution, in Christiansen, M. , Kirby, S. eds. Language Evolution, Oxford University Press

Bickerton, D. 2014 More than Nature Needs, Harvard University Press

Bybee, J. Slobin, D. 2004, From ontogenesis to phylogenesis, what can child language tell us about language evolution, in Langer, Parker, Milbrath, Biology and Knowledge Revisited: from neurogenesis to psychogenesis , Laurence Erlbaum Assoc.

Bloom , P. 2000, How Children Learn the Meanings of Words, MIT Press

Calvin , W. , 2001, Pumping up intelligence, in Sternberg, Evolution of intelligence , Abrupt Climate Jumps and the Evolution of Higher Intellectual Functions during the Ice Ages, in Sternberg, ed. The Evolution of Intelligence, Erlbaum , p. 97-115

Chomsky, N. 1980, Rules and Representations, Columbia University Press

Chomsky, N. 1986 Knowledge of Language, Its nature, origin and use, Greenwood Publishing

Chomsky, N. 1988, Language and the Problem of Knowledge, MIT Press

Corballis, M. 2011, The Recursive Mind, Princeton University Press

Comrie, B., T. Kuteva, 2005, The evolution of grammatical structures and “ functional need” explanations , in M. Tallerman, ed. Language Origins, Perspectives on Evolution, Oxford University Press, p. 166-185

Corning , P. 2003, Nature’s Magic, Synergy in Evolution and the Fate of Humankind, Cambridge University Press

Culicover, P. Jackendoff, R. 2005 Simpler Syntax, Oxford University Press

Deacon, T. 1997, The Symbolic Species, Norton and co.

Dediu, D. , Levinson S. 2018, Neanderthal language revisited, not only us, in Current Opinion in Behaviour and Brain Sciences, 21 p. 49-55

- Dehaene, S. L. Cohen, 2007, Cultural Recycling of Cognitive Maps, *Neuron Review*, 56, Cell Press, p. 384-398, Elsevier
DOI: 10.1016/j.neuron.2007.10.004
- Diamond, J. 1997, *Guns, Germs and Steel, the faith of human societies*, W.W.Norton
- Donald, M., 1993, *The Origins of the Modern Mind* , Harvard University Press
- Dor, D., Jablonka, E. 2001, From cultural selection to genetic selection, a framework for the evolution of language, *Selection* vol 1,issue 1-3, p. 33-56
doi: 10.1556/Select.1.2000.1-3.5
- Dunbar, R. 1997, *Grooming, Gossip and the Evolution of Language*, Harvard University Press
- Evans, V., Green, M. 2006, *Cognitive Linguistics, an Introduction* , Erlbaum
- Everett, D. 2005, Cultural constraints on grammar and cognition in Piraha: another look at the design features of human language, *Current Anthropology*, 46(4),p. 621-634
- Fedor, et all, 2009, What are the brain mechanisms underlying syntactic operations, in Bickerton,D. Szathmary, E.eds. *Biological Foundations and Origin of Syntax*, p. 299-324, MITPress
- Fisher,S., Marcus, G.2006, The eloquent ape, genes, brains and the evolution of language, *Nature Reviews, Genetics*, 7 (1)9-20
- Fitch, T. 2010, *The Evolution of Language*, Cambridge University Press
- Fodor, J. 1975, *The language of Thought*, Crowell Co. ;Harvard University Press
- Gardner, A. Gardner,B. Van Cantfort,T. eds. 1989,*Teaching Sign Language to Chimpanzee*, State University Of New York Press
- Givon, T. Malle, eds.2004, *Evolution of Language out of Pre-language*, *Typological Studies in Language*, John Benjamins
- Goddard,C. 2007, Semantic molecules, https://espace.library.uq.edu.au/data/UQ_127...
- Goldberg, A. 2003, *Constructions: a new theoretical approach to language*, *Trends in Cognitive Linguistics*, vol.7 no.5 ,p. 219-224
- Goldberg , E. et all. 1994, Lateralization of frontal lobe cognitive functions and novelty,

Journal of Psychiatry, vol. 6 , number 4, p. 371-378

Goldberg, E. 2001, *The Executive Brain: frontal lobes and the civilized mind*, Oxford University Press

Goldin-Meadow, S. 2002, Getting a handle on language creation, in Givon, T. Malle, *Evolution of language out of pre-language*, *Typological Studies in Language*, 53, John Benjamins, Amsterdam, p. 342-374

Goodall, J. 1986 *The Chimpanzees of Gombe, Patterns of behaviour* , Harvard University Press

Gulyas, B. 2009, Functional neuroimaging and the logic of brain operations: methodologies, caveats and fundamental examples from language research, in Bickerton D. Szathmari, E. eds. *Biological Foundations and Origin of Syntax*, MIT Press, p. 41-63

Haiman, J. 1983, Iconic and economic motivation, *Language*, vol. 59, No. 4 1983, p. 781-819

Haspelmath, M., 2007, Pre-established categories don't exist- consequences for language description and typology, *Linguistic Typology*, vol. 11, p. 119-132,
www.eva.mpg.de/fileadmin/content_files/staff/haspelmt/pdf/Preestablished.pdf

Haspelmath, M. 2008, Frequency vs. iconicity in explaining grammatical asymmetries, *Cognitive linguistics* 19(1), doi: 10.1515/COG.2008.001

Heine, B., T. Kuteva, 2007, *The Genesis of Grammar, a reconstruction*, Oxford University Press

Hopper, P, Traugott, E. 2003, *Grammaticalization*, Cambridge University Press

Hurford, J. 2012, *The Origins of Grammar, language in the light of evolution II*, Oxford University Press

Jablonka, E., Lamb, M. 2005 *Evolution in four dimensions*, MIT Press

Kaan, E. 2009, Syntactic phenomena and their putative relation to the brain, in Bickerton, D. Szathmari, E. eds. *Biological Foundations and Origin of Syntax*, MIT Press, p.117-135

Ke, J., Minett, J. W., Ching-Pong, Au, Wang, W. 2002, Self-organization and selection in the emergence of vocabulary, *Complexity*, vol.7, issue 3, p.41-54, Wiley Online Library

Keller, R. 1994, *Language change, the 'invisible hand' in language*, Routledge

Kuhn S. and Stiner M. ,1998, Middle Paleolithic “creativity” in Mithen, S. ed. *Creativity in*

- Human Evolution and Prehistory, Routledge, chap. 9, p.143- 159
- Langacker, R.2008, Cognitive Grammar, a basic introduction , Oxford University Press
- Lakoff, G. Johnson,M. 1980, Metaphors we Live By, University of Chicago Press
- Leaky, Richard, 1994, The origin of Humankind, Science Masters, Basic books
- Liebermann,Ph. 2002, On the nature and evolution of the neural bases of human language, Yearbook of Physical Anthropology, vol.45, 2002, p. 36-62 , doi: 10.1002/ajpa.10171
- Lieberman, Ph., 2006, Towards an Evolutionary Biology of Language , Harvard University Press
- Lieberman, Ph. 2007, The Evolution of Human Speech, its Anatomical and Neural Bases, Current Anthropology , vol 48, No.1. Feb. , p. 39-66
- Lumsden,Ch., Wilson, E. 1981, Genes, Mind, and Culture, The coevolutionary Process, Harvard University Press
- Mithen, S. ,1999, Problem Solving and the Origins of Human Culture, Institute for Cultural Research, Monograph series 33
- Noble, W. Davidson ,I. Noble 1996, Human Evolution, Language and Mind, a psychological and archeological inquiry, Cambridge University Press
- Richerson, P. ,Bettinger,R., Boyd R. , 2005, Evolution on a restless planet..were environmental variability and environment change major drivers of human evolution? in Wuketits,F., F. Ayala, Handbook of Evolution vol.2, Evolution of Living systems (Including Hominids) ,Wiley, Natural Sciences , chap. 7, p. 223-242
- Peperberg, I. 1998, Talking with Alex, Logic and speech in parrots, Scientific American, Copyright, Scientific American 2004
- Potts, R. Environmental hypothesis of human evolution,1998, Yearbook of Physical Anthropology, 41:p. 93-136
- Potts, R. 2013, Human evolution in settings of strong environmental variability, Quaternary Science Review, 73,p. 1-13
- Potts R. et all. 2018, Environmental dynamics during the onset of the Middle stone age in eastern Africa, Science vol. 360, issue 6384 p. 86-90, doi: 10.1126/science.aao2200
-

Sandler, W, Meir, I. Padden. C. Aronoff, M.,2005, The emergence of grammar, systematic structure in a new language, PNAS, 102, (7), p. 2661- 2665

Sauvage-Rumbough, S. 1986, Ape Language : from conditioned response to symbol, Columbia University Press

Schoenemann , T.,1999, Syntax as emergent characteristic of the evolution of semantic complexity, in Minds and Machines, 9, Kluwer Academic publishers, Netherlands , p.309-346

Schoenemann, T.,2005, Conceptual complexity and the brain, understanding language origins, in Minett, J., Wang, W.,eds.Language Acquisition, Change and Emergence, City University of Hong Kong, p. 47- 94

Searle, J. 1995, The Construction of Social Reality, Penguin Books

Shilton, D., Breski, M., Dor, D., Jablonka, E. 2020, Human social evolution, self-domestication or self-control, Frontiers in Psychology, vol.11, art.134, doi:10.3389/fpsyq2020.00134

Singha, C. 2009, Language as a cognitive niche and social institution, in Evans, Pourcel, eds. New Directions in Cognitive Linguistics, John Benjamins, p. 289-301

Steels, L. , A self-organizing spatial vocabulary, 1995, in Artificial Life, 2, MIT Press, p. 319-332

Tallermann M.et all, 2009 , What kind of syntactic phenomena must...replicate, in Bickerton, D.,Szathmary, E. eds. Biological Foundations and Origin of Syntax, MIT Press, p.135-161

Tomasello, M. 2008, Origins of Human Communication, MIT Press

Trestman, M. 2015, Clever Hans, Alex the parrot and Kanzi: What can exceptional animal learning teach us about human cognitive evolution? Biological Theory, 10, (86-99)

Wierzbicka, A.1992, Semantics: Culture and Cognition ,Oxford University Press

Williams, B., 2016, Effects of climate change on primate evolution in the Cenozoic , Education Knowledge, 7, (1):1

Zaefferer, D. 1991, Semantic Universals and Universal Semantics, Foris Publications

* Svetlana T.Davidova is a linguist, unaffiliated researcher based in Toronto, Canada with academic interest in the evolution of language
address for correspondence: svetlana.t.davidova@gmail.com
