# DOES HUMAN PHYSIOLOGY INFLUENCE THE LANGUAGE SYSTEM AND ITS EVOLUTION?

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ABSTRACT

Most linguists are convinced that the physical implementation of language, be it in speech, writing or gesture, does not influence the shape of language, as language is understood as a cognitive ability. That said, cognition and physiology exist and function in tandem in the human body and language is used by the individual's mind and body. Under the assumption that language structure is shaped by language use by the human individual as mind and body I present a counter argument that the modality, i.e. the channel of externalization, influences the language system through its influence on language use. Scholars discern two differently organized versions of language use, i.e. inferential system , usually externalized by speech, and code system, usually externalized by writing . Sign languages are naturally suited for face-to-face interaction. Each covers different language functions , in part influenced by the modality/channel of externalization . That said, given that sign language users live within a society where the overwhelming majority of humans are speakers, sign languages have developed grammatical complexity matching that of the code system to facilitate this communication. Thus, the organization of language is influenced by human physiology as perceptual-motor vehicle for externalization of the language system which partly determines the context of language use and is a contributing factor in language evolution.

Keywords: biolinguistics, functionalism, speech, grammar , writing, language evolution, UG

## 1. INTRODUCTION : language system and language use

Language is a system of symbols. Both dominant perspectives implicitly or explicitly converge on this assertion. Ever since Saussure lexical items are defined by their symbolic nature. The usage-based paradigm defines language as lexicon of constructions , i.e. accidental associations of form and meaning of various types and sizes, thus, by definition, a symbolic system. Even if one adopts the generative view of language which has consistently argued against the usage-based argument for the inherently communication-driven nature of the language system, at the same time defines language in terms of computation which is by definition manipulation of symbols. The computations in UG are by definition internally motivated structural relations, assembled by accident and insulated from perceptual experience, i.e. an essential aspect of symbols. Thus, language is indisputably a symbolic system.

Communication is an interaction between two entities where a signal is emitted with the expectation of exerting influence. In this sense any interaction , from a molecular level to digestion, to cognition and vocalizations is inherently an act of communication.

Communication is made possible by signs. Symbols are one type of signs. A symbol as a sign has two sides, a meaning, an abstract idea, labeled by a material form, an association formed

by accident of nature, as in warning calls, or human agreement, as national flags, aristocratic cotes of arms, linguistic forms.
Moreover, the very fact that language is a symbolic system implies that it is inherently a system for communication as the only reason for attaching a label to a concept is to make it detectable by an outside observer with the aim to exert influence, i.e to communicate. Thus, the very existence of symbols implies communication and language as a system of symbols is inherently designed for communication. Both the biolinguistic and the usage-based perspectives , although on the surface espousing mutually exclusive visions of language, in essence converge on the point that language as a system of symbols is therefore a system of communication, although the former defines it as communication within the human brain, while the later views it as communication among multiple brains.
Moreover, a system, any system, is designed around the traits of the processor. Language, is designed to reflect the nature of the human brain as a processor and the interaction among multiple brains. In the context of the usage-based/functionalist paradigm brains, in addition to processing language, also reflect the individual's experiences with the world encoded in linguistic meanings. All types of linguistic signs , from content words to the highly abstract grammatical rules , derive from examples of experiences. The function of linguistic forms and the language system as a whole is to communicate and share experiences. The existence of linguistic forms is justified by their functionality . It is on these theoretical foundations that I base my arguments in this paper. The philosophy of linguistic functionalism is most clearly articulated by Du Bois:
" Grammars provide the most economical coding mechanism…for those speech functions which speakers most often need to perform. More succinctly: Grammars code best what speakers do most. " ( Du Bois 1985 referenced inF. Newmeyer, 2003, p. 693 )
The language system at any historical period is understood to reflect its communicative function by striking a balance between maximum expressivity and minimum processing cost . Language is used for a wide variety of communicative functions, e.g., to explain complex ideas in scientific and philosophical argumentation , solve disputes, to entertain and inspire as instrument of artistic expression in fiction , poetry, etc. , to define ethnicities and individuals, to socialize by participating in casual conversations among friends and relatives. That said, they all fall into two fundamental functions, one, to encode, preserve and transmit information and another to form and maintain social relations . These two functions influence the shape of language. Language function influences all aspects of the language system , i.e. meaning, structure, as well as their material realization. If the language system is shaped by language use, " ...what speakers do most" ( ibid.) depends on the balance of communicative expressivity and ease of processing, including ease of articulation and perception.
I argue that the language system is influenced in part by the channels of externalization, i.e. speech, writing and manual sign . My goal here is merely to point at this previously neglected aspect in the study of language .

2. The function of encoding and preservation of information: the language system as a code

Meaning is sine qua non in any communication system. Linguistic theories offer two

competing theoretical alternatives in understanding linguistic meaning.
On the one hand, linguistic meaning is understood as a code designed in resemblance to other code systems , e.g. the morse code and artificial languages.
As such it displays the following characteristics:
*It is composed of linguistic primitives, members of a lexicon, as one-to-one stable associations of a meaning and a form, i.e. synonymy and homonymy is non-existent.
* these are defined by their membership in discrete and well defined grammatical categories,
* the so defined linguistic primitives are organized into sentences according to grammatical principles of grammaticality.
* the meaning of a sentence is the sum total of the meanings of the composing words and their place in the architecture of the sentence.
* A sentence is the encoding of a complete thought. Explicit and complete mapping between semantic structure and grammar is the norm. All thematic roles in the theta grid of a verb are expressed in grammatical categories. The agent consistently occupies the subject position in the sentence structure.
* It is self-contained, stands alone , independent of context of use. This facilitates the correct decoding of the meaning by people with vastly different experiences and views at any place and time .
* The sentence structure is highly detailed , it contains multiple embedding of phrases and sentences and highly abstract grammatical forms.
* The message for the sender and the receiver is identical.
* The code system assumes that communicators have identical minds.
* The function of code systems is mainly to inform, ergo, sentences are mostly statements.

3. The function of maintaining social relations: the language as inferential system

An alternative understanding of the language system is offered by the inferential model focusing on the following characteristics:
* The internal organization in inferential systems is information-based, not structure-based, that is, organized around information structure ( topic vs. focus)
* The building blocks of the system are flexible associations of form and meaning where standard meanings receive different interpretations depending on the specific circumstances of the context.
* They are organized into utterances.
* Most utterances are not full sentences but fragments, phrases are also fragmented. Despite these structural gaps the complete meaning of the utterance can be successfully recovered from the context.
* An inferential system is based on the assumption that participants are individualities with different minds and different life experiences in different communicative circumstances , which creates the potential for different interpretations of the same linguistic forms . This is why the meaning intended by the sender is most often different from the meaning understood by the receiver.
* The meaning of a sentence is different from the meaning of the utterance and the difference

between the two cannot be stipulated in advance by a code-like rules. In the inferential model utterances communicate the intended meaning in addition to the speaker's attitudes. Speakers' attitudes are categorized as a small number of illocutionary types ( J.Austin, 1962 ). e.g. statements, questions, demands/requests, mental states, ex. beliefs, doubts, and encoded in grammatical machinery, e.g. question phrases, modal verbs, etc.
* Sentence coordination is preferred, subordination is rare.
* Most verbs have incomplete argument structure with only a single argument.
* Omission of grammatical markers which do not contribute to the overall meaning and have only structural values, for example definite and indefinite articles in English, is one of the most notable characteristics.
* Elements of complex grammar with contribution to meaning : markers of plurality , modality, tense , aspect markers, case markers in languages with detailed case systems ( German , Russian, etc) are used as the context requires. Those with limited contribution to meaning are greatly simplified and often omitted .
* Small clauses, almost complete lack of embedding of phrases and sentences is the norm.
* These structural deficiencies do not prevent the full recovery of the intended meaning which is made complete by the context as the linguistic behaviour of the participants is a part of a wider context of communicative interactions which include non-linguistic behaviour.
* Utterances form part of spontaneous spoken dialogues mainly conducted in speech. Spoken dialogues are constructed by universal principles of cooperation in communication and general maxims of interpretation, outlined by Paul Grice . The meaning of an individual utterance is interpreted within the context of the dialogue by principles of relevance. (Wilson, D. 1998 ). The inferential system is designed on the assumption that all participants cooperate in the communicative process and adapt to one another. The communicators' linguistic behaviours are dynamic and fluctuate.
* Elliptical and abbreviated forms abound.
* Formulaic phrases are often used.
* Grammatically defective elements of unclear syntactic features, unclear morphological class and irregular phonology, or in Jackendoff's terms 'defective items' ( R.Jackendoff 2002) , 'mm', 'wow', 'sht' also abound.
* Semantically vague words and phrases, e.g.'that fellow', 'that thing', 'people' are often used.
*A liberal use of expletives is tolerated.
Inferential communication is conducted among people with close social ties which presupposes share knowledge of the world and society. It is realized by participation in spontaneous spoken dialogues which implies that the communicators have direct physical interactions and the linguistic communication is a component of a wider communicative complex which includes facial expressions, body movements, pointing gestures, etc. It is universally used by all speakers, regardless of ethnicity, culture , education , social status or profession.

Natural language is both a code and an inferential system demonstrated in every instance of language use. The correct i.e. intended interpretation of a message requires both decoding of the standard meanings of constructions and their intended meanings inferred from the active

contribution of the context. In each individual communicative act the code and the inferential component participate to different degrees and one or the other takes priority.

2. Three channels of externalization: speech, sign, writing

Language is a system of signs and as such it has an abstract component and a material one. The language system as abstraction is materialized by three material forms, speech, manual signs and writing and each interacts with the language system in a different way .

2 .1.The language system and the vocal -auditory channel

The overwhelming majority of linguistic interactions are conducted through the vocal-auditory channel in speech, thus, speech is the universal default channel for externalization of the language system.
The influence of the vocal-auditory channel on the organization of the inferential communication is as follows:
* The linguistic units are packaged in intonation contour. A sentence is organized to fit in a single prosodic contour. The boundary between a main clause and a compliment clause is marked by a pause.
* Extensive use of intonation assumes some grammatical functions, e.g. the formation of questions without the use of question words and/or other forms of grammatical machinery, e.g. subject-auxiliary inversion in English.
* The participants in spoken dialogues , often more than two, alternate their participation and continuously adjust their input accordingly.
* Speakers regulate their communicative contribution to fit a prosodic contour.
" ...spontaneous speech is typically not produced in a continuous stream. Speakers regulate the flow of information such that, in essence , they introduce just one new idea at a time per intonation unit or prosodic phrase. This new idea might be introduction of a new participant, action, time , place, or other new or significant item of information"( M.Mithun, in T.Givon, M.Shabatani, 2009. p. 67)

*The high speed of processing of speech exerts influence on the cognitive aspects of spoken dialogues. "...an intonation unit can express no more than one new idea. In other words thought, or at least, language, proceeds in terms of one such activation at a time, and each activation applies to a single referent , event, state, but not to more than one" (M. Mithun, citing W.Chafe 1994, in T.Givon , M.Shabatani 2009, p. 67).

Thus, vocal signals are ephemeral in nature and require high speed of articulation and comprehension, which imposes elevated demands on cognitive functions during processing. This imposes restrictions on the length and the semantic and grammatical complexity of the utterances, ultimately shaping the characteristics of language as a hybrid of a code and inferential system .

2.2. Sign languages and the visual-motor channel

Sign languages are newly formed linguistic systems which emerged as individuals with damaged speech capacities were brought together to form communities, instead of living in isolation. Because of their short history many are still in initial stages of development. There exist approximately 100 such systems around the world.
Sign languages are based on manual gesture and also utilize the movements of the whole body, posture, facial expressions. They are the best illustration of the influence of the human body as a whole on the shape of language.
Sign languages are two-tier systems where the role of manual gestures is parallel to that of speech sounds. The focus on sign languages has contributed to understanding human language by defining speech in terms of articulatory gestures, instead of sounds. ( Liebermann, Ph. 2006, 2007and elsewhere ). Semantics and grammar display no major differences from spoken languages . Interestingly, sign languages studied by science show preference for developing morphology, derivational and inflectional, with grammatical functions parallel to those in spoken languages ( H.Poizner, U.Bellugi, E.Klima, 1990; R.Campbell et all. 2007). Although the semantic and grammatical features of sign languages make them flexible enough to fulfill the functions of both code and inferential systems, gestures, like speech sounds, are ephemeral signs which makes them naturally suited for face-to-face communicative interactions, parallel to spoken dialogues. As such, they display all the usual features of language as a blend of code and inferential system. Signers learn the writing system of the surrounding speech community.

2.3.The properties of written texts and the visual channel

* The written text is composed of discrete and visibly distinguishable basic units, e.g. the letters of the alphabet or characters (in other types of writing systems) which are spatially organized . This encourages the perception of discreteness of linguistic elements.

* Letters are static and atemporal.

* Written texts are organized according to strict rules of grammatical correctness and conventions of punctuation.

* Individual linguistic units are identified by spacial separation on the page.

* The basic unit of linguistic organization is the sentence as linguistic encoding of a complete thought by clearly defined grammatical categories and principles of grammar.

* The sentence structure is highly detailed, contains multiple embedding of phrases and sentences , usually of considerable length and highly abstract grammatical forms.

* In written communication communicating parties are separated in space and in time and information is given, but there is no immediate information exchange.

* Written language is perfectly suited for disseminating knowledge which is why declarative speech acts dominate the written discourse.

* Generally lexicon items are one-to-one stable mappings of a form and a meaning, most often, literal meaning. Individual meanings are discrete and stable, intended to be interpreted

with minimum context information.

* The written text is self-contained, stands alone , independent of context , communicative and extralinguistic, which demands detailed and explicit exposition of the ideas it intends to convey.

* Written texts are monologues addressed to audiences separated by space and time which makes it suitable for exposition of universal and timeless ideas which makes the information conveyed by it constrained semantically.

Each of the three channels frame the language system in a specific way by emphasizing certain aspects of it at the expense of others.

2.4. Modality aligns with language function and influences the language system.

From all said so far it is clear that language as an instrument for communication must necessarily be highly sensitive to the goals of communicators. This determines the organization of a message, written, spoken or signed.
Indeed, code systems are well suited for articulating in a clear and concise manner complex ideas to audiences with diverse backgrounds and viewpoints, to defend or rebuke arguments in various spheres of public discourse. They serve the goal of dissemination of timeless ideas and as such is removed from the social and cultural idiosyncrasies of speakers' populations. Written texts are well suited for externalization of code-like language system. As the written text is static and permanent , unlike speech, which is ephemeral and not recoverable, it facilitates the intellectual, argumentative and informative functions of language. It encourages the dissemination and accumulation of knowledge across geographic and temporal boundaries.
Inferential systems are well suited for socializing through spontaneous spoken dialogues. Ordinary linguistic interactions are normally conducted among individuals wth close social ties and presuppose that the participants share world view, knowledge of the current situation which implies that non-linguistic communication has major contribution to the understanding of the message. The successful participation in spontaneous conversations in addition to knowledge of language, requires detailed knowledge of the local culture . It is well suited for communication among members of small communities with dense social ties.
In addition, intonation and stress, as properties of speech, fulfil some functions of grammar and contribute to the disambiguation of the message, given the natural time constraints of vocalizations.
Sign systems use the visual-motor modality which by definition makes it suitable for face-to-face spontaneous dialogues among individuals with highly similar life experiences by ephemeral signs . As spoken language, it utilizes its own intonation, stress, other prosody-like features which contribute to the interpretation of the message. In sum, the use of gestures in sign languages naturally aligns with the functions of inferential systems.
Thus, there is a consistent overlap between the channel of externalization and language functions.

2.5. Pre-literate languages and speech

This alignment of the properties of the language system with the channel of materialization is most clearly illustrated in the language systems which exist only in spoken form. These show properties distinct from languages with long literary traditions. Some examples of languages with no literary tradition are Piraha (D. Everett, 2005) and Riau Indonesian ( D.Gil 2007). A. Pawley ( in T.Givon, M. Shabatani, 2009) describes Kalam, a language spoken in Papua New Guinea as follows : major parts of speech are nouns, verbs, verb adjuncts, adverbs, adjectives , locatives. Verbs are the only part of speech to carry grammatical morphemes as inflection suffixes for marking tense, aspect, mood, person and number of the subject. The most common clause type is SOV. A complex predicate is encoded by a verb construction derived by attaching verb adjuncts to a single verb root. Arguments known or recoverable from the context or already mentioned in previous context are omitted. Serial verb constructions are formed as a number of verb roots united in sequence precede an inflected verb which carries all grammatical inflections for tense, aspect, mood and subject marking. The serial verb construction forms a single clause sentence . The most commonly used verb roots are short, composed of a singe syllable or even a single consonant. Serial verb constructions are used in narrative where information is presented in semantically and syntactically compressed forms.

M.Cysouw and B.Comrie ( 2013 ) outline some structural typological similarities among a number of languages spoken by small hunter-gatherer communities in Australia which are summarized as follows: * lack of dominant order of sentence constituents, word order is notoriously flexible and where there is such, it is non-SVO,*lack of adpositions, a few postpositions, *no dominant order of noun-genitive, preference for genitive-noun *interrogatives in initial position ,*subject clitics, *small phonological inventory

The common denominator among these languages is the reduced grammatical complexity, significant reliance on the extralinguistic context and speech as the only channel of material externalization.

Given this persistent co-occurrence of properties of the language system, spheres of language use and the material venues of externalization which involve physiological aspects of the human organism one is prompted to ask the question, is this a mere coincidence or it is an empirical demonstration of a causal relationship involving the human organism as body and mind . This will be discussed in the next segment.

3. Language use, cognitive and physiological aspects

When discussing language-relevant properties of the human organism, it is the anatomy of the brain and the cognitive capacities of the human mind that are most often in focus. That said, the observations detailed above prompt the speculation that , although the attention to the brain and its role as language processor is justifiable, language use is made possible by the human organism as a whole, and aspects of human physiology, through which the workings of the brain and mind are materialized and, thus, made explicit and accessible for study, are the other fundamental contributor not to be disregarded.

3 .1.The human brain and mind in linguistics

In linguistics competing theoretical alternatives understand the role of the human brain and mind in different terms. The generative/mentalist perspective argues for Universal Grammar ( Chomsky,1972, 1986 , 2000 among many other publications and lectures ) as innate property of the human brain, which determines a priori the shape of language. Scholars espousing the generative views points at the Broca's and Wernicke's regions as the most prominent locations of language processing activities.

The usage-based perspective argues that various properties of the human brain used in wide range of cognitive functions , e.g. memory storage and cognitive processes e.g. categorization, chunking, analogy, reduction, and other mechanisms of general intelligence influence the shape of language. It has been argued that language adapts to the brain's processing and learning tendency to achieve more with less energy cost. (M.Christiansen and N.Chater 2008 ; S. Kirby 1998 and elsewhere ). Thus, the biological foundations of language in the human organism are centred on the brain and cognition.

The seminal paper by Poizner, Bellugi and Klima (1990 )which demonstrates that sign languages have properties highly similar to those of spoken languages has been taken as a confirmation that the physiological properties of the channel by which the message is delivered are of no consequence in shaping the structure of language. The obvious fact that the brain exists and functions in the context of the whole organism is ignored.
That said, the human organism is an integrated complex, where the brain and the body influence one another. The human organism as a whole is a language user.

From a different angle, language as a system of symbols, has an abstract dimension and a material dimension. It can only function as communication system through its externalization by material signs. It is only through its material expression that we can glean knowledge about its abstract architecture. One cannot exist without the other. And these two aspects of language interact and influence one another. Language is a bio-cognitive behaviour and is made possible by the human organism as a whole which includes physiology.

In what follows I argue that besides the brain, human physiology and anatomy contribute in shaping the language system by influencing language use. In any type of communication sign production and interpretation place energy demands, both cognitive and physiological, on the body. Linguistic signs, both speech and manual gestures, are no different, suggesting that there is a direct co-dependence between the abstract language system and the material properties of channel of externalization.
The three channels of externalization writing, speech and gesture differ in their demands on the human body both in nature and magnitude.

3.2. Physiology matters: the perceptual-motor dimension of language use

Language use places highly energy demands on the organism, both cognitive and physiological, reflected in its spheres of use as the human organism will naturally look for

ways to minimize cost. Language is made possible by the interaction of the brain with the biological body, which imposes limitations of its own. These are not addressed in any meaningful way so far, a gap which makes our understanding of language and its bio-cognitive foundations incomplete.
The language system is influenced by language functions. These are highly influenced by the cost of processing , both cognitive and physiological. The physiological demands of language differ with the channel of externalization.

4.1.The physiological demands of spontaneous spoken dialogues

Casual conversations among individuals with close social ties occupy about 20% of all waking time of humans . Spoken dialogues is universally the most frequent form of language use ( J.L.Dessalless, 2007). The human organism has the ability to process spoken language with remarkable speed and accuracy. A linguistic item is processed on average as follows: 65 milliseconds (msec) for the processing of a phonological form, 250 msec for processing the semantics, 1-2 sec for processing the grammatical properties of a sentence ( T.Givon ,2002, p. 74). The demand for efficiency in articulation explains the fact that shorter forms are used with high frequency in all languages ( Zipf's law of word frequency). Thus, the physiology of speech influences language use.
The processing of spoken language includes both production and comprehension and the biological organism imposes limitations on each as each participant is both a speaker and a listener and language processing places energy demands on both physiology and cognition. Because language use is a negotiation between language production and comprehension, there must be a middle ground where the demands of both communicators are satisfied.
Participating in casual conversations most often accompanies leisurely activities which presupposes relaxed atmosphere. The spoken dialogue imposes relatively low cognitive and articulatory demands as it tolerates grammatical inaccuracies, conceptual vagueness, incomplete phrases , incomplete and often inaccurate pronunciation. In addition, in dialogues the participants, often more than two, alternate in their turn taking which means that the cognitive and articulatory effort is shared and thus, minimized even further. The cognitive and articulatory demands in this case are minimal and inaccuracies and mistakes are of little consequence for the accuracy of message comprehension.

Although casual dialogues are physiological activity of relatively low energy cost, narration in spoken form as long spoken monologues, e.g. speeches, lectures, etc. are rare communicative events because they cause physiological exhaustion for the speech organs.
Physical efforts in speech production are greatly alleviated by the invention of writing, where the physiological cost is minimized by replacing it by the less energy-demanding visual channel, making the dissemination of information more energy-efficient.

4.2.The physiological demands of the code systems and writing

Casual dialogues have less informative value as participants are individuals with close social ties who share common believes, assumptions, world knowledge, cultural values, i.e. common ground. In addition, in direct interaction some information is contributed by the active participation of extralinguistic means, e.g. by gesticulations, etc. which acts as a substitute and/or complement to the linguistic message, further reducing the informative burden on the language system . Because in impromptu spoken dialogues the priority is given to socializing and the information exchange is not purely linguistic, there is limited necessity for developing language complexity, semantic and structural.
Communication among individuals in the absence of common ground demands that meanings must be made explicit by linguistic forms. These are the communicative circumstances in a "society of strangers"( Givon T. 1979, 2002 and elsewhere) , i.e. when communication is between individuals beyond the immediate family circle and the functions of language are extended, giving priority to information exchange. The increased demand for linguistic communication is met by extended vocabulary which, in turn, leads to internal restructuring of the language system by introducing highly abstract concepts in elaborate structural associations producing multiple phrasal and sentential embedding.
Increase in language complexity brings high cognitive demands on the brain beginning from the memorization and retention of a large vocabulary and careful selection of the most appropriate lexical and grammatical forms, brought by the demand for the detailed and precise exposition of sophisticated ideas . All this requires focus, time-consuming deliberations and meticulous selection among alternative variants by the sender. In addition, equally high cognitive demands are required from the receiver by the need to evaluate the ideas of the author and contextualize to one's own knowledge and experience . Thus, substantial cognitive demands are imposed on the brain by the demands for clear and detailed exposition and evaluation of complex ideas in linguistic terms on both sides .

The elevated complexity of the language system requires not only cognitive energy by both sender and the interpreter, but also imposes elevated physiological demands for clear articulation on the speech organs which adds to the overall energy demands on the body. The fact that sound is ephemeral and fades away rapidly puts additional pressure on the memory of all participants. This explains the fact that this type of activity is restricted to rare instances of language use. Speeches are rare events, television and radio shows, if monologues, are interspersed by commercial brakes, lectures are restricted in duration.

The increase of the number of potential communicators in a large open " societies of strangers" and the demand for language complexity and articulatory precision demonstrates, among other things, the limitations of the vocal channel and prompts the invention and proliferation of writing. Letters, as stable signs, replace sound as ephemeral medium, which significantly alleviates the cognitive pressure of immediacy on the brain by allowing time for precision in encoding the ideas by the sender and accuracy in decoding by the receiver. In this way the cognitive energy of both participants is distributed over time allowing the dissemination of complex ideas without the investment of a great deal of cognitive energy. Moreover, given that reading and writing place much lesser physiological demands than speech, the physiological cost is also minimized greatly. The invention of writing is an effort

to facilitate communication across space and time by minimizing the physiological cost for the author while increasing exponentially the effect by multiplying the receivers of information, who can be miles away in distance and centuries apart in time. Writing allows complex ideas to be preserved and shared across generations for the benefit of all humanity. Writing is at the bedrock of all great civilizations.

In short, the elevated demands for increased use of language require elevated cognitive and physiological expense from all participants . Humans have invented writing, a new and very efficient channel of externalization in effort to minimize physiological cost while maximizing the effect of knowledge dissemination beyond the limitations of space and time.

Interestingly, exposure to writing influences language processing by the brain.
The idiolect , i.e., the linguistic competence of the individual mind is emergent from the unique linguistic experiences of each individual. One such significant influence is education and literacy, thus, exposure to writing . Exposure to written texts alters the individual's perception of language as strings of discrete spatially arranged discrete characters ,i.e. letters of the alphabet , Chinese characters, glyphs, etc. The perception of the sound stream as a string of phonemes and the conception of the phoneme, or any other writing symbol, as abstract concept appears to facilitate abstract thought as literate individuals are found to be more inclined to form abstractions as compared with illiterate counterparts.
"...the vividness of our intuitions about the segmental organization of speech is largely a consequence of training in reading and writing with an alphabet ." ( Port, 2007, p. 153 ).
Moreover, it was found that the brain of the signer processes language differently than that of the speaker (R. Campbell et all. 2007)
Thus, human physiology making possible the material aspects of linguistic signs influences brain activity during language processing .

4.3.The physiological demands of processing in sign languages

While the physiological demands of speech production are minimal, one can reasonably anticipate that the production of sign gestures place much higher energy demands on physiology. And although I cannot offer precision of numbers as to how many calories the body utilizes in the articulation of speech vs. sign production , the physiological demands of manual signs are comparable to those of everyday physical activities , e.f. gardening, running, etc. if one is to use a relevant point of reference. In this context, as a general principle of biology, the biological body imposes limitations on physical activities e.g. limits on speed of running.
The elevated kinetic demands of manual signs essentially prohibit the use of sign language in long speeches as this would lead to physical exhaustion. This naturally limits the use of sign language to short conversations. I have not witnessed and am not aware of speeches performed in sign languages. If such endeavour would be attempted it would be a unique event .
Moreover, if sign languages are used regularly for prolonged conversations, the physiological demands on the hands and the entire body would force significant simplification of the signs which would favour the sender, but compromise its expressivity and create ambiguity which

inevitably would create more obstacles in comprehension for the receiver. This also explains the fact that speech and not sign language is the default channel and is only used when the vocal-auditory channel is unusable, as a solution of last resort , not as alternative to speech . To recap, the language system is influenced by the perceptual-motor channel of externalization.

Speech is ideally suited for casual conversations among close friends and relatives where much information remains implicit. Spoken interactions are conducted in dialogues where the cognitive and physiological effort is distributed among multiple participants as they take turns. Moreover, spoken linguistic interactions are interspersed with stretches of silence which often is a signal in itself and contributes to the overall meaning of the conversation making the message even more energy-efficient. In addition, the fact that spoken conversations are conducted face -to-face also helps to infer the intended meaning by the facial expressions and/or body signals of the participants. In this way the physiological load is distributed among multiple aspects of human physiology in all participants which is the most convenient and energy-efficient way of language use. This explains the fact that spoken conversations are universally the most preferred mode of communication in humans.

Speech and manual signs influence linguistic structure in different ways. Both vocal and manual signs are ephemeral which restricts the length and complexity of the message and makes them suitable for short face-to-face communicative exchanges. That said, speech and gesture are also very different in their energy demands to the human body. Speech is cheep to articulate as the kinetic energy demands to human physiology are minimal which explains the fact that evolution has favoured adaptation of human physiology to spoken language. That said, the physiological demands of speech, and especially on manual gestures, make these not suitable for long sentences with complex embedded structures and especially for narrative .

On the other hand, it is clear that the elevated demand for communication among strangers, structurally organized into code-like systems and implemented in writing, encourages semantic precision and grammatical complexity. Moreover, written texts reduce cognitive demands and minimize physiological efforts, an efficient way of mass dissemination of knowledge in service of civilization.

This brings the conclusion that the demands of language processing, both production and comprehension, to the human organism are not only cognitive but also physiological and both influence the language system and the spheres of language use.

Moreover, from evolutionary perspective the language system has evolved in coordination with the human organism which has evolved not only cognitively but also physiologically to facilitate language processing . This will be the topic of the next segment.

## 5. Language evolution and human physiology

Understanding the present helps make inferences about the past, especially the distant past for which material traces are scarce. Understand the influence of human physiology in language today could help understand the role of human physiology in language evolution and the overall human speciation.

Proponents of the generative/mentalistic perspective argue that the channel of externalization has little relevance to the evolution of the language faculty as the linguistic computations are by their definition encapsulated and insulated from influence of externalization ( Chomsky, 1972, 1986, 2000) . Others argue for interaction of human cognition an physiology in language evolution( Ph. Liebermann, 2000, 2006, 2007, 2008 ). Two major criteria are considered: a. compatibility of human physiology with the design features of language as determined by the dominant theoretical perspectives, b. compatibility of human physiology with the fundamental principles of biology focusing on evolutionary continuity. That said, different scholars focus on different aspects of human physiology relevant to language evolution, to be discussed briefly in the following segment.

5.1.Gesture first: the argument for gestural origins of language

Various scholars have advanced the argument that linguistic communication originated in the gestural modality and only later became spoken.
It is based in part on the direct observation of spontaneous formation of newly emerging sign languages, interpreted as a demonstration of innate predispositions for gestural sign system. M.Corballis ( 2009, 2009a) , M.Tomasello (2008) infer the potential usability of manual gestures for the production of linguistic signs from the fact that manual signs in modern sign languages display the most defining features of language, e.g. signs are discrete , combinable , learned in ontogeny, intentionally produced and used referentially in situation-independent way. Scholars who adopt the gesture-first hypothesis also refer to the fact that human physiology shows coordination between control of hand and mouth as speech is normally accompanied by subconscious manual gesticulations. Moreover, spacial proximity between Broca's area, almost unanimously recognized to have significant involvement in language processing, and the area controlling the movements of the right hand, suggests a natural connection between processing of language and manual gestures in the architecture and functioning of the brain ( Corballis, 2003 and elsewhere )
Moreover, evolutionary continuity between aspects of language and manual gesticulations are suggested by archeological findings of Oldowan and Achewlian technologies which demonstrate impressive manual dexterity of pre-human ancestral species revealing capacities for hierarchical organization in praxis. These are hypothesized to have been co-opted for communicative use in mimetic communication in Homo Habilis and Erectus as a precursor to modern syntactic language (K. Sterelny, 2012)
Additional signs of continuity are found in primate communicative behaviour in natural settings demonstrating that primate use of gestures is much more sophisticated than their vocal communication. Significantly, primates are trained to use sign gestures which displays some of the features of human language: gestures are learned during ontogeny and intentionally used, situation-independent, in occasions combined and new gestures are invented. ( S.Savage-Rumbough 1986 ). In contrast, primate vocal signals are understood as innate emotional, holistic responses to specific situations, fixed in number, new vocalizations are never learned ( Tomasello 2008 and elsewhere ). In addition, the fact that with training primates are able to learn the basics of human sign language but not speech appears to

strengthen the argument.
Comparative studies in brain architecture and functions of humans and modern apes demonstrate that area F5 in the monkey's brain controls manual as well as oro-facial movements. This justifies the assumption of a homological relation between the area F5 in the monkey's brain and Broca's area in the human brain, well known to be involved in the control of the coordination of speech and manual movements ( Tomasello 2008 and elsewhere )
Corballis ( 2009 , 2009a and elsewhere ) attributes the current dominance of spoken language to a genetic mutation in the FOXP2 gene at about 200,000ya which produced its human version of the gene and resulting in transfer of control over the vocal tract to the Broca's area and opening the way for evolution of modern speech.
G.Rizzolatti and M.Arbib " (1998 ) attribute a prominent role to mirror neurons in gestural origins of language which help explain the connection at neuronal level between sign perception and production. The mirror neurons are also said to have a role in the capacity to interpret gestures as signs, thus, constituting a precursor to protogesture as a subsequent stage in primate evolution and a precursor to symbols. A neurological event involving mirror neurons is hypothesized to have resulted in a behavioural shift in replacement of gestural communication with some form of proto-speech resulting in a " language-ready brain"which facilitates the formation of vocabulary and propels the development of spoken lexical protolanguage (Arbib M. 2007 , 2017 ),which as per Bickerton have preceded the evolution of grammar .
Critics focus on the fact that gestural communication is useless in the dark and at a long distance. Manual gestures also have high energy demands , compared to speech. In addition, communicative use of gestures interferes with practical use of hands in tool use.
Moreover, critics ( J.L. Dessaless 2006, p. 143 , P. MacNeilage, 1998 ) point at the fact that people, deaf or not, never spontaneously begin using sign language before learning spoken language. Dessalles ( 2006, p. 143 ) also points at the difference between gesticulations accompanying speech and sign language, the first bearing resemblance to an instinct, the second having all the characteristics of language as compositional, intentional , conscious communication. Moreover, the overwhelming majority of natural languages are spoken while sign languages are an exception in that , although they are natural languages, equivalent in expressive power and structural sophistication to spoken languages, they emerge in very specific circumstances when the speech capacities are damaged as a solution of last resort. Sign language is learned only in case when the biological equipment enabling speech production and perception is damaged, as a substitute for speech, and not by choice. There is no case when a human community physiologically capable of speech has chosen to invent and use sign language.
The argument faces additional difficulties explaining how the switch between the two modalities in the form of instantaneous transfer of motor control from hands to vocal tract has occurred during the evolution of homo sapience as such switch is not reflected in the anthropological record .

5 .2. Phylogenesis of speech

Speech is the universal channel for linguistic communication in the overwhelming majority of language varieties . It is a very specific type of vocal signal, unusual in various ways: acoustically, physiologically, cognitively , developmentally. Acoustically, it is different from non-speech sounds as detected by acoustic equipment. Physiologically, it is consisting of rapid change of formants, produced by the rapid and coordinated movements of the organs in the vocal tract ( Aaltonen, 2005, Pinker Jackendoff , 2005, 2009 ).

It is represented in the human organism in a unique way. Anatomically, the ability to produce speech signals requires not only a specific type of anatomy, but also a specific type of neural connectivity . E.Lenneberg ( 1967) shows that various traits in the human anatomy and physiology are perfectly fit for use in speech. T. Fitch ( 2010 ) points out that the human tongue has a unique shape and position in the mouth, the speech organs have unique physiology, e.g. they are very flexible, allowing rapid production of maximally distinct vocal signals, achieved by species' specific breathing control, tied to speech production. See also M.Studdart-Kennedy in J.Hurford, M.Studdert-Kennedy, Ch.Knigth, 1998 ) . Speech is the result of coordination of vocal organs and their control by the brain. In this context the evolution of speech capacities is understood as evolution of human vocal tract from a collection of independently functioning and individually controlled parts into a unified complex of coordinated and interdependent vocal organs which act in concert. Ph.Liebermann ( 2006, 2007and elsewhere ) presents convincing arguments that speech was a selective force which drove the evolution of a consciously manipulated and highly agile vocal tract , able to produce sufficiently distinguishable discrete sounds which were made available for representing concepts.

Moreover, infant babbling, a key part of human language development, which Hurford ( 2011) argues is a developmental instinct, evolved as adaptive response to a culturally formed communication , adds more strength to the argument which ties evolution of language with the evolution of speech.

In arguing for the evolutionary advantages of speech as a plausible evolutionary target during human speciation biologists focus on the long evolutionary history of vocal signalling and find evolutionary continuity of speech with animal vocal signals. There is ample evidence for the deep evolutionary roots of speech as continuity both in sound production and perception in various species , some quite distantly related to sapience. Combinatorial vocal signals are demonstrated in birds, some marine animals and even bats and elephants viewed as possible precursors for speech (Hilliard, White, 2009; Schraff , Petri, 2011, p. 2125).

Liebermann has consistently argued that Neanderthals had speech capacities similar, although not identical to humans' as they weren't' able to pronounce the so called quantal vowels. Ph. Liebermann ( 2006, 2007, 2008 ). Others argue that Neanderthals were "... fully articulate beings.." and had all the necessary attributes of human language speakers. ( D.Dediu, V. Levinson, 2013, 2018 ).

In sum, evolution has prepared the human biological body genetically, anatomically, developmentally for speech. As Liebermann concludes, "Without speech... complex language would not be possible" ( Lieberman , Ph. 2008, p. 219, ).

Although this line of inquiry focuses on the aspects of externalization of the language system,

Liebermann has argued extensively for the connection between the brain regions responsible for motor control of the vocal tract and those responsible for linguistic structure, among other non-language -relevant behaviours. He states that "...The FOXP2 gene is clearly implicated in the formation of neural circuits that regulate the human cognitive and motor capacities ( in Ph.Lieberman 2007, p.52)
Liebermann (2016) argues that the FOXP2 human version of the gene is involved in the phenotypic formation of the human basal ganglia, which is responsible for rule-governed complex structures both in cognition and praxis. In this context the evolution of the speech capacities is understood as integral component of the evolution of language and features prominently in human speciation.
Human cognition and physiology are interacting and interdependent in the human organism. The capacity for speech was found to be a vital component of the language capacity ( Liebermann, 2007, 2016; S.Pinker, R.Jackendoff, 2005, 2009) .The KE family members with impaired capacity for grammar have also demonstrated impaired speech capacities.
Lieberman , P. suggests that the FOX2P gene has a role in language phylogeny as participant in the formation of the vocal tract and speech. He states that "...The FOXP2 gene is clearly implicated in the formation of neural circuits that regulate the human cognitive and motor capacities ( in Lieberman 2007, p.52) .
Thus, capacity for speech is a component of the language capacity which involves the coordinated evolutionary adaptation of the human organism for language learning and processing.
From a linguist's perspective speech is viewed as compatible with the symbolic nature of linguistic signs , and thus, its flexibility and learnability. In addition, the discreteness of speech sounds makes possible combinatoriality of phonology which makes discernible the individuality of each Saussurean sign.
Currently the unimodal arguments are dominant in the literature.

5.3. Multimodal perspective on language evolution

Yet another alternative is offered by the argument for a multimodal beginnings of human communication ( M. Donald,1991; V. Levinson ,J. Holler 2014; B. Waller, et all, 2013; K. Slocombe, et all, 2011 ), stating that simpler semantic content was transmitted initially by the whole body, including vocalizations, via referential and iconic gesticulations, facial expressions. The argument relies on comparative studies illustrating that modern primates' communication is multimodal, e.g. chimps in captivity communicate with signals emitted simultaneously from a variety of modalities as they recognize and produce visual, tactile, vocal signs in their communication with caregivers , thus, demonstrating continuity with pre-human communication (K. Slocombe, B.Waller, K.Liebal 2011 ). Given that modern human speech is constantly accompanied with non-verbal signals which clarify and add detail to the intended message, this argument is plausible and suggest a new angle to the continuity debate in language evolution.
That said, multimodality in face-to-face spoken dialogues and in sign languages have high energy demands to human physiology which , overlaid upon the cognitive demands of

linguistic communication , constraints its use to the context of " society of intimates" . In addition, the high energy demands of multimodal communication to the human organism adds to the energy demands of the biological body required for its biological subsistence ,e.g. supplying nutrition, personal defence, etc. which would overwhelm the organism and make the use of language by no means beneficial to the overall survival of the biological body. This suggests that a multimodal communication system of much lesser semantic and structural complexity than modern language would have been in existence at the time of language origins.

Subsequent demands for increase of information content and with that demands for semantic and structural complexity, associated with the use of language in a " society of strangers" would inevitably have increased the cognitive and physiological demands to the organism which would have made the continuation of multimodal communication prohibitively energy inefficient and even detrimental to the survival of its users and as such, unlikely target for evolutionary improvements. Following this line of thought, the focus of evolution on the physiological elaboration of the vocal channel as the most energy-efficient materialization of linguistic signs can then be seen as the most likely response to the physiological and kinetic limitations of the human body via adaptation for speech and the resulting universality of spoken language.

Spoken dialogues as the universally preferred form of linguistic communication are delivered mainly, but not exclusively, through speech, with other additional channels. e.g. gesture, facial expressions, voice pitch , etc. as contributors. This suggests a strong possibility that language must have evolved from a semantically and structurally simpler multimodal communication by gradually increasing the role of speech, making it the dominant modality, while decreasing , although not eliminating, the participation of other modalities, leaving for them a supporting role. Thus, the increasing role of communication and the natural limitations of the human body explain the emergence of speech as the main channel of linguistic communication.

The human individual as a language user is a biological body as well as a member of a community. The shape of language is influenced by both these factors. In the following segment I will argue that the nature of communicative interactions determined by the community types influence the material side of the language complex.

### 5.2. Language evolution, civilization and writing

Language use is influenced, among other factors, by the communities who use it .The social organization in them is instrumental in determining the nature of interpersonal relations and interactions. And because in human groups members are language speakers, their economic , political, social relations are reflected in the nature and extent of their linguistic interactions and as a consequence, the language systems they use. For example small isolated communities are usually composed of individuals genetically and/or ethnically related who share common world view and life style and who know one another personally and anticipate each other's intentions . This entails that a good part of the information is shared and what is new and worthy of communicating is minimal. Small communities are also known for little social stratification, as members behave and communicate as equals. Communication is usually in the

form of direct face-to-face spoken exchanges which entails that any potential for misunderstanding caused by linguistic ambiguity can be easily resolved.
A number of scholars have argued that there is not only a correlation but a causal connection between social organization and the language system . Marsh ( 1967) ,Keenan and Comrie, ( 1977) ),J. Hurford ( 2012) quotes studies by P.Trudgill, A.Wray, G.Grace, among others, show that languages spoken by small isolated communities tend to have smaller vocabularies, develop complex morphologies and simple syntax. They also develop less complex deictic systems as in face -to-face conversations participants have direct access to the details of the communicative situation which precludes the need to explicitly encode these in linguistic terms . Lexicons and grammars in languages of small communities are also less transparent, e.g. contain more irregular forms, explicable by the fact that in small closed and stable populations social norms are easily enforceable and maintained. In this sense elaborate linguistic forms , like cultural traditions, despite being difficult to learn, are easy to maintain generation after generation .
In contrast, large societies are ethnically diverse and their members share little communicative common ground. Such societies are known for sophisticated social structure, detailed social stratification, which, naturally, creates informational imbalance and with it the need for precision and detailed exposition in communication.
Consequently, languages spoken in large societies which require a large part of the communication to be at a physical and/or temporal distance create the demand for large vocabularies, increased number of refined grammatical categories and elaborate syntax. In addition, large ethnically diverse societies, open to migration and, consequently with large number of adult second language learners create the demand for transparency in word formation and regular morphology, thus, facilitating adult language learning.
In these circumstances a large part of communication is at a physical and/or temporal distance, eliminating the contribution of multimodal channels, essential in spoken face-to-face dialogues and thus, transferring the majority of information lead to the language system. Consequently, as a substitute for the absence of a vital contribution of non-linguistic communicative venues, languages have adapted to the communicative demands of large societies by developing large vocabularies, refined grammatical categories, transparency in word formation, regular morphology and elaborate syntax and more code-like features.
T. Givon ( 1979 ;T. Givon, B.Malle, 2002 ) argues that the evolution of language can be conceived of as transformation from inferential, i.e meaning-dominated, to code-like, i.e. structure-dominated language system. The tightly organized and highly regularized , ergo, easier to learn, grammatical structure makes for accurate and effective transmission of the message in response to the elevated demands for detail and precision of linguistic communication in the “society of strangers”.
The fact that transformation from inferential systems to code-like systems historically coincides with the invention of writing cannot be treated as a mere coincidence.
A demonstration of the influence of social organization of the language system and its evolution in modern time was provided by D. Gil ( 2009) in his analysis of Riau Indonesian, which, as a colloquial variety used in Sumatra spoken by multiple millions of people “represents the limiting points of maximal simplicity within each of the three distinct domains ,

morphology, syntax and semantics." ( Gil, ibid. p. 2) On the other hand, he states that a variety of Riau selected to be used in maintenance of government institutions e.g. government documents and official government affairs, not unexpectedly, has developed grammatical complexity , in response to its new role in the emerging complex society.
Sign language users are in a similar situation. Sign languages were initially formed as inferential systems, perfectly suited for their natural role in direct face-to-face communicative interactions among individuals with common experiences, i.e. a " society of intimates" . Nevertheless, signers are at the same time members of a larger society of language speakers, where they function as citizens, workers, neighbours. This means that there must be constant translation between the two types of languages, the signed and the spoken. Because the language of the larger society, which is spoken, is dominant in its social functions, it is natural to expect that sign languages would develop grammatical complexity similar to that of the language of the larger society, a normal process of language change as a result of constant language contact . As in a large diverse society communicative cohesion is vital, this makes the development of grammatical complexity in sign languages essentially inevitable. An example of that are events of emergency, e.g.natural disaster, war, when the timely and accurate translation of government instructions in sign language are of paramount importance. In this sense, the original claim by H.Poizner, U.Bellugi, E.Klima ( 1990) that sign languages are independent of the spoken language of the surrounding community is not supported by these facts. Thus, there is constant interaction and interdependence among the language system, social organization and the cognitive and physiological aspects of language use.

## SUMMARY AND CONCLUSIONS

The goal of the present article is not to underestimate the role of the brain in language processing, far from it. It is merely to remind that the human organism functions as a unified complex , the brain works in coordination with the rest of the body in concert with human anatomy and physiology. In this sense the human body as a whole is a language user and a processor. Language is both facilitated and constrained by the human organism both cognitively and physiologically. Language is shaped by the internal organization and energy demands of the human brain and human physiology and constantly adapts to its demands as they change. Moreover, given that language is a system of signs, the abstract component necessarily must exist in coordination with the material component. In his sense the biolinguistic argument which currently focuses on the role of the brain and mind in the formation and maintenance of the language system must be enriched by understanding the influence of human physiology.
From an evolutionary perspective human cognition has evolved in concert with human anatomy and physiology to process language. As language has evolved it has modified the human body both cognitively and physiologically. In this sense the argument that human physiology influences the language system through the channel of externalization has potential implications for the study of language evolution both as phylogenesis and glossogenesis. Importantly, ignoring the role of the material side in the overall shape of the language system is a deficiency in linguistic theorizing which contributes to the difficulties un

understanding language and language evolution.

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