GRAMMAR CHANGE – A CASE OF DARWINIAN COGNITIVE EVOLUTION

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Abstract

Structurally, cognitive and biological evolution are highly similar. Random variation and constant but blind selection drive evolution within biology as well as within cognition. However, evolution of cognitive programs, and in particular of grammar systems, is not a subclass of biological evolution but a domain of its own. The abstract evolutionary principles, however, are akin in cognitive and biological evolution. In other words, insights gained in the biological domain can be cautiously applied to the cognitive domain. This paper claims that the cognitively encapsulated, i.e. consciously inaccessible, aspects of grammars as cognitively represented systems, that is, the procedural and structural parts of grammars, are subject to, and results of, Darwinian evolution, applying to specific cognitive programs. Other, consciously accessible aspects of language do not fall under Darwinian evolutionary principles, but are mostly instances of social changes.

1. Evolution – from metaphor to materiality

Nature.com introduces the topic as follows: *"Evolution of language* is *the gradual change in human language over time* [...] *and can be considered analogous to biological evolution, although it does not necessarily occur through the same mechanisms*." And thus, the very article deems the analogy to biological evolution to be loose. Language change is filed under "c*ultural evolution",* which *"is the change over time of non-biological aspects of human society. The process is loosely analogous to biological evolution* [...] *and includes changes in language, art and social behaviour and norms*." In contrast to this appraisal, the present paper argues that grammar as a *neuro-cognitive* phenomenon is subject to the *very same* mechanisms of Darwinian evolution, in a different domain, though.

The formal & structural makeup of languages is defined by their grammars. Grammar, as understood here, is an essential part of a cognitive "program package" underlying and constituting the activities in language use and acquisition. Changes in grammar are changes in a cognitively encapsulated, neuro-cognitively implemented program, that is, changes in a "cognitive app" for language processing, in perception, production and crucially also in acquisition. It will be argued that *Darwinian evolution* of the neuro-cognitively encapsulated aspects of grammars is essentially involved in the origin and the changes of these programs. Darwinian evolution is the result of constant *selection* operating on a pool of random *variations*. In the case of a cognitive 'organism', the target of selection is a neuro-cognitively represented, self-replicating program, namely the "grammar app".

Not all changes in languages are instances of Darwinian evolution. Consciously accessible aspects of languages, as for instance the continuous changes of preferences in the domain of lexical items and their morphological shapes, are open for conscious interventions since they are accessible. Their characteristics of change are different, and an adequate theory of language change has to differentiate between changes in the computational *program* and changes in the *inventory*. To put it briefly, changes in the *program* are Darwinian, changes of the consciously accessible lexical *inventory* are not.

In a declarative & procedural model of grammar, whose neuro-cognitive basis has been described in Ullman (2001), Darwinian evolution shapes the procedural component. This comprises the structural make-up as well as the processes that operate on these structures. The declarative components are open for socially motivated changes. These two domains – the procedural and the declarative one – are not isolated, of course. When changes in the declarative domain feed variation, this may also feed the domain in which Darwinian selection is at work. On the other hand, changes in the procedural domain are typically the predecessors of the reduction of declarative coding, due to increased redundancies.

The following two subsections prepare the ground for the discussion. Section 1.1. presents grammar as a neuro-cognitive program package that functions as a *cognitive virus*. It 'infects' a host system which it is dependent on for replication and which thereby happens to function as the selecting environment. Section 1.2 reviews current usages of the concept of "evolution" in language change, ranging from loose analogies to approaches that elevate the principles of Darwinian biological evolution to principles of a metatheory of evolutionary processes in fields other than biology. In biology, Darwin's theory has prevailed over Lamarck's theory, but in other fields, notably in socio-cultural provinces, Lamarckian concepts have survived or been revived, with mixed reactions, ranging from acceptance to disapproval.

1.1 Grammar as a cognitive-virus program[1]

Grammars are essential components of programs for the effective computing of linguistic symbol systems. Grammars are components of software packages, or in present day jargon, "apps" for language production and reception. They are part of a (domain-specific) linguistic co-processor that supplements the capabilities of the (domain-general) primary processor, i.e. the general cognitive information processing functions. The major computational problem it solves is the fast and effective back & forth mapping from 1D-to-2D. The acoustic signal is ordered linearly, one-dimensionally, due to the phonetics interface, but the structure of propositions is at least a two-dimensional object: portions of the linear array (1D) are grouped into hierarchically organized box-in-box-structures (2D). In production, 2D-structures are mapped back onto 1D ones. A grammar is the program for this dimension management, mapping the linear arrays back and forth from linear to hierarchically organized symbol structures efficiently and effectively.

Languages are used for cognitive and communicative functions, but grammars provide and constrain the linguistic tools based on the neuro-cognitive capacities that govern their acquisition and communicative use. From an evolution-theoretic point of view, a grammar is – even literally – a cognitive virus program. It is *self-replicating* but for its successful replication, it is dependent on a host, which it 'infects' in the course of grammar acquisition. On the one hand, the grammar virus-program governs our language processing capacity, but at the same time, language usage is the reproduction device for the virus. Grammar is contagious. Children's brains get 'infected' and acquire grammar on the basis of being exposed to language productions and they put their acquired grammar to use. Afterwards, their productions become part of the input for the next generation's acquisition of grammar, and so on.

Such reproduction processes are necessarily imperfect. An inevitable by-product of inaccurate acquisition of the grammar app is (micro-)variation. Variation – as in the case of mutations in

[1] This section draws on Haider (2019a), (2015a) and (1991).

the biological instantiation of evolution – is enhanced by various other factors, including language contact or dialectal segregation. What this scenario amounts to is an instance of Darwinian evolution that operates on the level of cognitive structures and their variants.

Researchers interested in the "evolution of language" traditionally focus on the *biological* features on the one hand and speculate about their *communicative* use on the other hand.[2] As a consequence, too little is known about the true ground zero of the evolution of grammars, namely the evolution of cognition capacities in general and in particular the evolution of grammar systems as a central part of our cognitive capacities, namely language processing.

Evolution inexorably results in adaptation to the selecting environment.[3] The selecting environment for grammars is the ensemble of neuro-cognitive computation capacities of our brain that has been recruited for language processing in homo-sapiens brains. It determines whether a grammar variant receives a bonus or not. The history of evolution of the domain-general cognitive system is independent of language. Hence selection for the grammar program is constant and blind selection by a superordinate system that is not pre-designed for language processing. In the evolution of humans, complex grammars of languages are too recent an achievement to be a result of *biological* selection on its own.[4]

Language processing has always been parasitic on already existing computation capacities of the human brain which have come into being well before these brains started with language (Christiansen et al. 2009). This set of capacities is a selector in the ongoing adaptation of grammars to their neuro-cognitive processing environment. Grammar variants that can be more easily acquired or more efficiently put to use, will eventually 'infect' more brains than other variants in the long run. As a consequence, grammars will be optimized for learnability and on-line usability step-by-step, but randomly, since the initiating of such steps is an accidental moment in evolution. It is not driven by any urge for improvement.

Here is an example of the recruiting of already available brain resources for language processing. Broca's and Wernicke's area in the language-dominant hemisphere are hotspots in the cortical language processing circuits. But they are not homo-sapiens innovations.

"*Our findings support the conclusion that leftward asymmetry of Wernicke's area originated prior to the appearance of modern human language and before our divergence from the last common ancestor.* (Spocter et al. 2010: 2165). "*Broca's and Wernicke's areas, and the arcuate fasciculus connecting them, were not specially evolved for language*" (Schoenemann 2012:455).

The replication of the cognitive representation of a grammar resembles the replication of a virus. It is totally dependent on a host. Only a virus that successfully recruits a host is able to induce it to produce copies.[5] So, the host is at the same time the vehicle and the selecting envi-

[2] "*A look at the literature on evolution of language reveals that most of it scarcely even addresses the topic. Instead, it largely offers speculations about the evolution of communication, a very different matter*." (Chomsky 2011:265; or: https://www.physicsforums.com/threads/mind-body-problem-chomsky-nagel.523765/page-18)

[3] This is a corollary of Fisher's theorem. "*Assuming that natural selection drives all evolution, the mean fitness of a population cannot decrease during evolution* (*if the population is to survive*)." (Koonin: 2012:8).

[4] In comparison to songbirds (Brenowitz 2008), our brains are not a priori 'hardwired' for language processing. The brain functions and brain regions recruited for language processing support other functions, too, and moreover, they are functioning in the brains of our nearest relatives as well, for instance in bonobo brains, in the absence of complex grammar processing capacities.

[5] For a briefing see Goulding (2020): Adsorption, entry into the host cell, transcription, and subsequent replication by synthesis are the essential steps. https://www.immunology.org/public-information/bitesized-immunology/pathogens-and-disease/virus-replication. [March 15, 2020]

ronment. This is where natural selection operates (cf. Rubio et al. 2013). *"Viruses* [...] *experience strong and diverse selective forces, sometimes acting on timescales that can be directly measured*." Spielman et. al. (2019: 427). Variants that succeed in capturing a host will survive and increase their frequency (= positive or adaptive selection), whereas variants that do not succeed will decrease in frequency (= negative or purifying selection).[6]

Our layman's perspective on viruses is entirely negative because of our perception of their pathogenic effects.[7] Because of negative selection, natural selection fuels a continuous arms race between hosts and the virus. The host wins whenever its immune system prevails and the virus wins whenever it is able to outwit the defence system. Like cell-based life, a *biological* as well as a *computational* virus is subject to evolution by natural selection. With respect to reproduction, however, there is an essential difference between viruses and complex life forms. Life forms reproduce by their own, viruses are unable to reproduce without a host.

The pathogenic perspective has been taken up by Sobin (1997), who coined the term "grammatical virus" as a device that reads grammatical codes and affects them negatively.[8] Sobin's virus metaphor for external and 'pathogenic' influences on grammar has been carried on by Lasnik & Sobin (2000) to the *who/whom* alternation, by McKenzie (2013) to participle-object agreement in French, or by Sundquist (2012) to Norwegian negation. In all these instances, the virus metaphor is used for characterizing a grammatical phenomenon as alien to the grammatical system and 'pathological'.

In the present paper, a grammar is regarded as a positively selected virus program, that is, as a 'mutualistic' virus (see below) supporting the general cognitive system. Unlike pathogenic viruses, a mutualistic virus is selected positively. Here are biological counterparts. Roossinck (2011: 99 and 106): "*Although viruses are most often studied as pathogens, many are beneficial to their hosts, providing essential functions in some cases and conditionally beneficial functions in others*." Roossinck and Bazàn (2017) call the symbiosis with mutualistic viruses an "intimate partnership", and such is the partnership between the domain-general human cognition and the domain-specific grammar app.

This paper favours the concept of a grammar as a viral system in a *symbiotic*[9] relation with domain-general cognitive capacities of our brain. A grammar needs the cognitive capacities of our brain as a host and replicator, but it the opposite of pathogenic. It works as the core program of the domain-specific cognitive device for language processing. Such a viral program package is necessarily subject to the selective effects of the host system in the process of replication. Selection has the effect that grammars as cognitive systems adapt to the cognitive capacities they depend on: "*Overall, language appears to have adapted to the human brain more so than the reverse*" (Schoenemann 2012: 443).

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6 Because harmful changes are more frequent than beneficial ones, negative selection plays an important role in maintaining the long-term stability of structures by removing deleterious variants (Loewe 2008:59).

7 Rhino, influenza, Ebola or Corona viruses are notorious. These lines have been written during a pandemia curfew.

8 See Schütze (1999) for a rejoinder. Sobin proposes an analysis of prestige constructions of English, such as plural agreement in expletive constructions, as a result of a "grammatical virus infection", a process that operates "*out of conformity with the principles that govern the proper devices of a grammar*" (Sobin 1997: 319).

9 Symbiosis $=_{\text{Def.}}$ two entities living in an intimate association (Roossinck 2011: 99).

1.2 Evolution – Disambiguating a transposed concept

When evolution is invoked in linguistic settings, the first approximation typically is the borrowing of a prestigious concept for a metaphoric narrative, as a façon de parler without strict adherence to the theoretical apparatus of the biological theory of evolution. On the other side of the spectrum, there is "generalised Darwinism". This perspective pursues and develops a domain-general theory of Darwinian evolution and domain-specific implementations of the general theory.

1.2.1 Evolution as metaphor

"Loosely analogous" approaches (see the introductory Nature.com quote) import biological terminology but re-construe it metaphorically. Haspelmath (1999), for instance, regards diachronic changes as evolutionary processes since – as he argues – the fact that changes in biology and in linguistics are often adaptive, which, in biology, is explained as a result of Darwinian evolution, would suffice to turn language into a domain of evolutionary change: "*I argue in this paper that linguistic adaptation is in many ways analogous to biological adaptation*. [...] *As in biology, observed adaptive patterns in language can be explained through diachronic evolutionary processes as the unintended cumulative outcome of numerous individual intentional actions.*" (Haspelmath 1999:186, 180).

The characterization as "*cumulative outcome of numerous individual intentional actions"* makes instantly clear that "evolution" in this view cannot be Darwinian. In Darwinian evolution, adaptive patterns result from *constant* but *blind* selection operating on a pool of *random* variants. There is no teleology or intentionality involved;[10] see Hanke (2004) for details. Darwinian evolutionary explanation explicitly rejects any goal-orientation. "*Darwinian evolution is completely myopic*" (Simon 1996: 47).[11] Adaptedness is a result (a posteriori) rather than an (a priori) target of goal-seeking activities (Mayr 1992).

The same is true for grammars. Individual users are incapable of intentionally changing their acquired grammar since they have no access to its parts and pieces. These are cognitively encapsulated and users are not aware of the specific grammatical conditions that govern their own verbal behavior. They are aware of the output of the system but not of the intricate details of the make-up of the system that account for the output. They may (intentionally) choose between alternatively available output variants, but this, by itself, is not a change of grammar. It is a source of variation, though, which prepares the ground for Darwinian selection. What seems to

[10] What appears to be teleology – see Kant (1790: §68), on "*Zweckmäßigkeit ohne Zweck*" (purposiveness without purpose) – is adaptation as the effect of constant but blind selection. "Evolution" without a selection environment cannot be Darwinian evolution (Haider 1999), since (natural) selection is the essential component.

[11] "*Evolution depends on two processes: a generator and a test. The generator produces variety, new forms that have not existed previously, whereas the test culls out the generated forms so that only those that are well fitted to the environment will survive*." Simon (1996: 45). "*At each incremental step the evolving organism becomes fitter relative to its current environment, but there is no reason for the progress to lead to a global maximum of fitness of the individuals, separately or severally.*" Simon (1996: 47).

be taken for granted under such a perspective is the synchronization and qualitative transformation of the "individual intentional actions". "Functional selection"[12] as a consequence of usefulness or functional need[13] is claimed to be responsible for the proliferation of specific variants. "*High-frequency structures may become obligatory, and low-frequency items may be lost as a result of their (high or low) frequencies*." "*Entrenchment due to frequency thus corresponds to selection in biology*" (Haspelmath 1999: 190).

In Darwinian theory, frequency is not a cause but a potential effect. Higher frequency is the result of selection if a variant expands in a population because phenotypes with this particular genetic variant happen to contribute to a higher reproduction success. If "frequency selection" were part of Darwinian evolution, novel variants would never have a chance of spreading since they would disappear in the population already at the beginning as a result of their necessarily low initial frequency. Frequency selection is a maxim of a debunked theory, namely Lamarckian evolution (see sect. 1.2).

A crucial aspect of Darwin's theory tends to be neglected in all these analogies, namely the mechanism of *retention* of traits, independent of their frequency in the population. This is an essential ingredient of the theory of Darwinian evolution. This issue has already been raised forcefully in the early days of evolution theory by Jenkin (1867), known as the "swamping argument". Jenkin objected to Darwin's theory by pointing out that an accidentally appearing profitable variety could not be preserved by natural selection. It would be 'swamped' by the ordinary traits in the course of backcrossing in the population. Darwin (1872: 71-72) accepted the objection as the most valuable one he had ever read (Morris 1994: 313). It took half a century for the theory to remove this difficulty. The weak point was the by-now replaced idea of inheritance as a *blend* of traits of the parents. Genetics provided the necessary insights for replacing *blending inheritance* by *Mendelian inheritance*. What is inherited is not a phenotypic trait but an information package in terms of genetic information passed on to progeny. When expressed, it accounts for the inherited phenotypic characteristics. A variant (i.e. a dominant allele) is coded in the cells of its carrier and therefore it is immune against being swamped. The offspring will inherit it and will be able to pass it on, even in a community in which no other individual than mother or father originally carried this variant. What is described by "*entrenchment due to frequency*" in linguistics is not an ingredient of Darwinian evolution but rather a characteristics of the rapid diffusion of innovations and artefacts in society.[14]

Under primarily usage-based perspectives, language design tends to be (mis-)perceived as a human artefact. The grammar of a language is apparently regarded much like a kind of open-source rule-book that is open for collaborative public efforts of improving on it. However, this analogy fails. The source code of our language processing cognitive software is cognitively encapsulated and inaccessible. It is cognitively as inaccessible as the genetic code. Even if I

[12] *Functional selection* (Nettle 1999: 30-35) rests on the notion that some variables may confer fitness because they make language easier to learn or use. Note that in Nettle's view, the gain in fitness goes to the *language user*, and crucially not to the grammar. In this paper, selection in terms of 'fitness' is a competition between grammars as cognitively-based systems in competition for replication, that is, for learning brains. The bonus goes to *the grammar* for features that confer an advantage to brains in language acquisition or use.

[13] Comrie & Kuteva (2005) object to functional-need explanations on detailed empirical grounds.

[14] It accounts, for instance, for the worldwide spreading of frozen pizza, certain smart phones, or body piercing, but not for the cross-population dynamics of self-reproducing systems and their variants. The former is social behaviour rather than the effect of natural selection.

desired to change it, I couldn't do this by intensive wishful thinking. Analogously, we cannot intentionally change the grammar as a mental software. What can be intentionally changed is the behaviour, that is, the choice between items a grammar makes available when we use language. In use, patterns may be blended, but not grammars. If grammars were open to constant intentional interventions aiming at enhancing their compatibility with all kinds of user demands, grammar change should closely resemble changes in traditions, life-styles, and fashion, which it does not.

What is missing in such pictures is the essential ingredient of the neo-Darwinian theory of evolution, namely the mechanism for the *retention* of a novel and therefore necessarily infrequent variant in the population. This mechanism is essential since it guarantees that there is a pool of variants exposed to constant selection. If the population could not retain infrequent but favourable traits within this pool, they could not gradually spread as a consequence of sieving out less favourable variants, independently of their frequency, by natural selection. Increase in frequency is not the cause of selection but its gradual effect.

Darwinian evolution is a mechanism with two essential components in a feed-back relation, namely the genotype and the phenotype. Natural selection has no direct access to the genotype. Unlike genetic engineering, it does not manipulate a particular trait of the genotype. Selection acts on the pool of phenotypic variations in a *population*. The phenotype is the vehicle of the genotype. The spreading of a particular genotype in a population is the effect of environmental conditions that amount to a bonus program in the reproduction of the carriers of a particular genotype. In the case of language, the genotype is the given grammar as a cognitively represented system and the phenotype is speech, that is the output of and input to the system in action. The *selective* environment for natural selection in the case of grammar is *not* the social environment (see below). Let me duly emphasize this essential point: The selective environment for grammars is the neuro-cognitive environment in which the grammar system is cognitively embedded, that is, our human neural information processing system.

Finally, the crucial reproduction rate is of course not the sexual reproduction rate of the speakers who have acquired a particular grammar variant, but the *cognitive reproduction rate* of a grammar variant in terms of the number of brains which acquire and use a given variant rather than a competing one. Genes spread by *sexual* reproduction, grammatical traits spread by *cognitive* reproduction. The counterpart of the *genome* could be called the *'grammome'*, that is, the whole neuro-cognitively represented information structure that gears the linguistic capacities of a language processing brain.

1.2.2 Lamarckian vs. Darwinian evolution

One of two central theses of Lamarck's theory of evolution (Lamarck 1809) is *entrenchment due to frequency* of usage is. This thesis is known as "*the law of use and disuse*", whereby individual life forms gradually change their traits in proportion to the extent that they are used or not. The second thesis is the "*law of the inheritance of acquired characteristics"*. Lamarckism assumes inheritance of acquired characters as an inherent property of all living organisms. In other words, experiences during lifetime are transformed into heritable features of an individual. Changes are triggered and directed by environmental needs and traits can be acquired and passed on through the efforts of individual organisms, with the effect that organisms gain or lose functions that they need or have no use for, respectively (Johansson 2005: 16).

In today's evolutionary biology, epigenetic effects sometimes are equated with acquired traits that become inheritable, much like what Lamarckian theory assumes.[15] Haig (2007: 415) objects and argues that epigenetic inheritance expands the range of options available to genes but evolutionary adaptation remains the product of natural selection of random variation. Loison (2018) emphasizes that molecular mechanisms of transgenerational epigenetic inheritance themselves are evolved products of natural selection. "*This means that the kind of inheritance of acquired characters they might be responsible for is an obligatory emergent feature of evolution, whereas traditional Lamarckism conceived the inheritance of acquired characters as a property inherent in living matter itself.*"

A third ingredient of Lamarckian evolution is a complexifying, *goal-seeking force* which is the source of the emergence of new organs in the course of time. If new requirements make themselves felt, they lead to the development of new structures and their upkeep and maintenance.

In today's biology, Lamarck's concepts are of historic interest only, but in cultural studies, they are still adduced for interpreting cultural changes, not always in a homologous way, though. For qualifying as Lamarckian evolution, properties acquired at the phenotypic level would have to be encoded in the genotype that is passed on to the next generation. It is not sufficient to appeal to "use and disuse" and a goal-oriented behavior. The appropriate term for this would simply be "social learning".

"*Social learning would be literally Lamarckian if the knowledge that an organism acquired about its environment somehow came to be encoded in its genetic material and thereafter was inherited by its progeny. As far as I know, none of the advocates of an evolutionary analysis of conceptual change view social learning in such a literal fashion. The whole point of social learning is that information is transmitted independently of genes.* [...] *Inheritance is not involved (just transmission)".* (Hull 1988: 37).

The crucial point of Lamarckism is that it is a doctrine that admits the possibility of (genotypic) *inheritance* of *acquired* (phenotypic) characters by individual organisms in evolutionary processes. Consequently, a social replicator (as the analogue of genotype) has to be identified, with a view on exploring the distinction between genotype and phenotype at the social level. If in the course of cultural changes, practices are invented, used, accumulated and *directly* passed on to others by social means of communicating such knowledge, this is not Lamarckian evolution.

In linguistic terms, the concept of acquired 'inheritable' traits could be interpreted as follows. If the 'genotype' of a given language (variant) corresponds to 'cognitive grammar of a language (variant)', any phenotypic character is the reflex of a genotypic character. Hence, an *acquired* genotypic character in the Lamarckian sense is a character which is triggered by a change in the environment and subsequently coded in the grammatical 'genotype' during lifetime. This means that a language user would have to be able to change an already acquired grammar into a new grammar anytime in life and then pass it on. So the crucial question is this: Is a speaker

[15] Szyf (2014) reports an inheritable effect of fear-conditioning of mice up to two generations under the title "Lamarck revisited" in Nature Neuroscience.

able to (intentionally) change the grammar of the language (s)he has acquired in first-language acquisition in a significant way?

It is the main claim of this paper that the cognitively encapsulated parts of grammar are inaccessible for changes after first-language acquisition. They can only be patched up locally but not changed. Local changes are possible only in the accessible domains of the *inventory* (i.e. lexicon and morphology), but not in the *procedural* domain (see section 3.1 for details).

Haspelmath (1999: 192) admits that linguistic evolution might be "*entirely Lamarckian*" and concludes that "*structural adaptation in language must be due* [to] *the effect of constraints on performance combined with a mechanism that turns preferred options of language use into structural patterns of grammar*."

Such a statement is not convincing. If "*preferred options of language use*" were the trigger for structural patterns of grammar, then the past millennia of usage would have been sufficient for streamlining any language.[16] Consequently, languages whose users share preferred options of use due to their shared culture and life form would have become structurally highly similar. Conversely, if grammars widely differ in their structural patterns, such as for instance Chinese, English, Japanese, and Russian, this ought to reflect differences in "*the preferred options of language use*". This is neither empirically evident nor theoretically plausible.

Let me pick just a single structural difference for illustration: Why would English (and many other languages, such as every Romance null-subject language), but not Japanese (and many other languages, such as German), rule out passivization of intransitive verbs? For a detailed discussion see Haider (2019b). Isn't there any demand for intransitive passive in Britain or Spain, but a strong need in Japan and Germany? Why could there be such sharp differences in the "*preferred options of language use*" persisting over centuries? The availability of such constructions is not a question of language *use* but of the particular system of *grammar* that is compatible (or at odds) with the results of passivizing intransitive verbs.[17] For analogous considerations with respect to relative clause structures and tense systems see Comrie & Kuteva (2005).

1.2.3 Generalized Darwinism

Generalized Darwinism or universal Darwinism is the collective term for a variety of approaches that extend the Darwinian theory beyond its original biological domain, with linguists as early adopters (Schleicher 1873). In social sciences, evolutionary economics has become a proliferating field[18] (see Hodgson and Knudsen 2006, Nelson 2007, Hodgson 2011, 2013), although economics arguably is an unlikely terrain of success for such an approach. The dynamics of economic behaviour lacks the two essential mechanisms of conserving and retaining of traits ('inheritance') on the one hand and on the other hand it lacks a constant and blind selection

[16] Note that evolution has no predictable time course. Changes depend on the existence of variants and their coming into being is not timed. Long periods of steady states may be followed by a period of variation and change; see Eldredge & Gould (1972) on punctuated equilibrium in sect. 5 below.

[17] If the standard passive is applied to an intransitive verb in an [S[VO]] language, the subject position must be filled with an expletive subject. If the language does not provide one, passive cannot be applied to intransitives. In no Romance null-subject standard language, intransitive verbs can be passivized.

[18] In 2006, the *Journal of Evolutionary Economics* devoted the issue 16(5) to evolutionary concepts in economics and biology; see the editor's statement (Witt 2006); for a literature review see Breslin (2010).

mechanism as background. Darwinian evolution does not work with moving targets. It is not surprising therefore that the Darwinian economists face fierce criticism. "*We wonder how "Generalized Darwinism" can be made fruitful for evolutionary economics given that its principles are but an abstract hull that does not suffice to explain actual evolutionary processes in the economy." [...] "We find little evidence in the literature for the claim that Generalized Darwinism can enhance the explanatory power of an evolutionary approach to economics*." (Levit et al. 2011:1).

The unifying bond for Generalized Darwinism is the perspective of a generalized version of the mechanisms of *variation, selection and retention* so that it lends itself to a common general framework for studying evolutionary processes not only in the biological domain but also in other fields. Hodgson and Knudsen (2008: 51) summarize the essential point of this desired theory as follows: "*It is proposed here that Darwinism provides a general, meta-theoretical framework for dealing with complex evolving systems, consisting of populations of varied and replicating entities, which are found in both nature and human society. There is no alternative to the core Darwinian principles of variation, selection and inheritance to explain the evolution of such systems. Darwinism includes a broad theoretical framework for the analysis of the evolution of all open, complex systems, including socio-economic systems*."

The shared theoretical background must contain a self-replicating system with sources of variation plus a way of retaining variants, and an environment that exerts a constant selection effect. The ultimate aim is a general theory of evolution with domain-specific implementations. In social sciences these prerequisites have not yet been shown to hold. Without them, an explanatory Darwinian approach is not feasible. Cognition and neuro-cognition is a much more likely field for arriving at a successful and explanatory evolutionary theory that is based on the fundamentals of Darwinian evolutionary theory.

2. Mechanisms of evolution in biology

In the popular understanding, evolutionary change is equated with the result of natural selection and the "*survival of the fittest*". However, selection is not the only and in some instances not even the most frequent mechanism of generating changes. Genetic *drift* and *gene flow* are essential factors as well. The homologues of drift and gene flow are non-negligible in language change as well.

2.1. Darwinian evolution[19] by natural selection

Darwin's theory of evolution by natural selection, as summarized by Mayr (1991) and Gould (2002), consists of five independent sub-theories. Here is a brief summary, with asides on the linguistic parallels of each sub-theory.

i. *Evolution as such*: Organisms transform over time. They are neither constant nor perpetually fluctuating. Grammars of languages are cognitive systems that are known to transform over time if not impeded by normative efforts (schooling, norms of script culture, etc.). Changes are typically not fluctuating but in many cases directional and irreversible for a given language.

ii. *Common descent*: Each group of organisms descended from a common ancestor, and all groups of organisms ultimately can be traced back to a single origin of life on earth. As for

[19] This section draws on Haider (2015a).

languages, Indo-European studies are a success story of this point. Languages that descended from a single proto-language have spread as far as to Iceland in the West and to a province of China in the East (Tocharic) within several millennia.

iii. *Multiplication of species*: This theory postulates that species multiply, either by splitting into daughter species or by budding, that is, the establishment of founder populations that evolve into species, if geographically isolated. „Species“ and „subspecies“ translate into „language“ and „varieties of a language“, such as dialects. An example of budding under geographic isolation is the split of language due to migration (cf. Afrikaans, in comparison with Dutch).

iv. *Gradualism*: Evolutionary change proceeds gradually and not by sudden (saltational) appearances of new complex systems. Sudden changes are not excluded, though.[20] In linguistics, this is commonplace. Grammar change is gradual, usually spanning many generations. Changes typically develop out of areas with dialectal variants co-existing for a long time.

v. *Natural selection*: Evolutionary change comes about through the proliferation of (genetic) variation in every generation. If individuals have more offspring thanks to a well-adapted combination of *inheritable* characters, these characters spread in the population. Selection sieves out less well-adapted characters.

This sub-theory is the crucial one. Linguists who would subscribe to i.-iv. would not simultaneously endorse natural selection as the mechanism of language change and the emergence of new species (= separate languages). What would it mean that "individuals" with a specific grammar variant thrive and that this variant thereby spreads?

The sceptics focus on an inappropriate concept of "*individuals who thrive*". Obviously, this concept must not be interpreted as "*individuals who use a given language*", even if linguists tend to interpret it that way, for instance Pinker & Bloom (1990), Nettle (1999), Solan et al. (2005). Nobody has been able to produce reliable evidence for changes in grammar with a significant effect on the reproductive success of the *users*, conferred by the preference of a particular language variant.[21] The relevant "individuals" in the context of grammar evolution are the individually embodied *cognitive representations* of a grammar variant in the brains of language users. These are the "individuals who thrive" and spread in the population of language-using brains, and this is the relevant effect of cognitive evolution.

Darwinian evolution is change by selection operating on a pool of variants. For grammars as cognitive systems, the primary selector is a child's processing brain when it acquires the grammar of a given language by being exposed to utterances shaped by this grammar. Like in biological evolution, the winner is the grammar variant of the given language that successfully 'invades' more brains than competing variants. The winning variant multiplies itself more often. And just like in biological evolution, the emergent result is often an accumulation of adaptive qualities relative to the selecting environment, that is, the neuro-cognitive environment.

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[20] There are phases of less gradual changes (cf. Eldredge & Gould 1972), and "*organisms with a profoundly mutant phenotype that have the potential to establish a new evolutionary lineage have been termed 'hopeful monsters'*." (Theißen 2009: 43).

[21] The crucial issue is not 'having a language' vs. 'no language', but the selection between grammar variants. Furthermore, sharing an individual language may have social benefits, but this reduces variation. It does not explain the actual choices.

What are adaptive qualities in such an environment? The natural environment of grammar is language acquisition and language processing. As in biology, selection becomes a crucial issue once there is competition for limited resources. Limited resources are storage, time, and effort. A limited resource, for instance, is the amount of processing expenditure needed for a given structure. There is a *bottleneck effect* in reception. "*Sequential information, at many levels of analysis, must rapidly be recoded to avoid being interfered with or overwritten by the deluge of subsequent material. To cope with the Now-or-Never bottleneck, the language system chunks new material as rapidly as possible at a range of increasingly abstract levels of representation*"; see Christiansen & Chater (2016, sect. 7). If a competing variant can be processed more easily and more quickly, the responsible grammar variant is likely to gain an advantage by being selected in the course of language acquisition.

However, just as in biology, the need by itself does not create the grammar variant it would prefer. A species may retain the same form in its environment for any amount of time if the environment does not change radically and no rival variant emerges that competes for the available resources (cf. the species of coelacanths). There is no adaptation without variation. If there is variation, the higher the rate of variation, the higher the potential for adaptive changes, as Fisher's theorem tells (Fisher 1930: 35).[22]

2.2. Flow and drift

Gene flow, drift, and natural selection are distinct mechanism, but do not exclude each other. They may operate separately or simultaneously and influence each other. Drift may prepare the ground for selection, for instance, and gene flow may reduce variation and thereby hamper selection.

Gene flow (also known as *gene migration* or *allele flow*), is the exchange of genetic material and consequently of genetic variation between different populations.[23] The linguistic counterpart is the dynamics of grammar changes in multilingual populations, between dialects of a language or between different languages in language contact areas. Extensive bilingualism, see Heath (1984), Thomason & Kaufman (1988), Winford (2003), is a well-recognized variation-prone situation. Take for instance modern Persian. Numerous grammar changes which separate modern Persian from Eastern Iranian kin-languages like Pashto took place after the Arab conquest with ensuing Persian-Arabic bilingualism, accompanied by the introduction of Arabic script. "*It was not only lexical elements that entered Persian: Arabic morphological and even syntactic features also found their way into the language*." (Gazsi 2011: 1015).

Genetic drift – also known as allelic *drift* or *Sewall Wright Effect* – is a mechanism of evolution by which allele frequencies in a population change *by chance* (e.g. random births, deaths, and Mendelian segregations in reproduction). Newberry et al. (2017) characterize the linguistic analogue as follows: "*Unlike selective forces, which bias a language learner towards adopting forms that are intrinsically easier to learn or more effective for communication, drift arises*

[22] "*The rate of increase in fitness of any organism at any time is equal to its genetic variance in fitness at that time*."

[23] "*Gene flow tends to oppose the effects of local selection. However, it can also replenish the local population and local genetic variation, which are both pre-requisites for evolution by natural selection*." (Lenormand 2002: 189).

purely by chance: the learner chooses randomly among the sample of forms that she happens to encounter."

Genetic drift is the result of random sampling among variants. The variants in one generation do not reproduce in equal ratios in the next generation. Drift is an evolutionary process, but it is evolution due to chance, not selection. Nevertheless, drift can lead to significant changes over a short period of time in small populations. The linguistic *parallel* to genetic drift is the random nascence of grammar variants which is enhanced by segregation of subpopulations of the speech community, for instance by migration.

A word of warning is appropriate here: The concept "drift" in population genetics must not be equivocated with Sapir's (1921) notion of "drift". Sapir's notion is the exact opposite of the genetic notion since Sapir's characterization of drift is actually a paraphrase of the effect of natural selection: "*The drift of a language is constituted by the unconscious selection on the part of its speakers of those individual variations that are cumulative in some special direction."* (Sapir 1921: 166).

What Sapir describes is the interplay between random *variation* and constant and therefore *directional* selection and *retention*. This is the essence of Darwinian natural selection operating on grammatical systems: "*It by no means follows that the general drift of language can be understood from an exhaustive descriptive study of these variations alone. They themselves are random phenomena. The linguistic drift has direction. In other words, only those individual variations embody it or carry it which move in a certain direction*." (Sapir 1921: 165)

3. Elements of a Darwinian *cognition-based* evolution of grammar

3.1 Grammars as cognitive systems are susceptible to variation and selection.

The expression "Darwinian cognitive evolution" in the title should be read as follows. Darwinian evolution, that is natural selection among variants of a self-reproducing system, applies in the variation range of a cognitive program, that is, the cognitively represented grammar, with the domain-general computational capacities of the brain as the constant selector environment of the 'viral' grammar.[24] As a viral system, a grammar needs and employs the general cognitive capacities of our brain for reproduction and these capacities impose their restrictions.

Just as in biological evolution, reproductive success is a function of the dissemination of particular variants. In biological evolution, success is measured by the number of descendants. In cognitive evolution, the descendants are not the result of sexual reproduction but the result of a viral reproduction process. If a grammar is indeed a (mutualistic) cognitive virus, its reproductive success is measured like the success of any virus namely by the number of hosts it 'infects'. The more brains a grammar variant enters and occupies when these brains acquire a language, the more replicas of this grammar variant will be passed on to learners of the following generation, when they acquire their grammar based on the utterances of the previous generation governed by the particular grammar variant, and so on. An immediate result of this selection-based processes is the adaptation of human grammars to the properties of the processing brains as the

[24] For Darwin (1872: 59), it was beyond doubt that his selection-based theory of evolution is substance-neutral. It operates on self-replicating biological organisms in the same way as it operates on cognitively represented self-replicating 'viral' processing programs. "*The formation of different languages and of distinct species, and the proofs that both have been developed through a gradual process, are curiously parallel*."

selecting environment. This is the familiar effect of adaptation by natural selection in Darwinian evolution. An essential feature is still missing in this sketch of the evolution of a cognitive grammar program subject to natural selection. It is the mechanism of the *retention* of a variant in the population. In the biological case, a variant is retained because it is coded in the genome of its carrier as an allele.[25]

In genetics, an allele is one of the possible forms of a gene. In grammar, an allele is one of the possible 'pieces' of grammatical information that is 'expressed' (in the technical sense of gene expression) in the formation of a particular utterance. That grammatical features can be successfully treated as alleles has been shown in studies that apply algorithms developed in populations genetics to studies of linguistic diversity, such as Reesink et al. (2009) or Greenhill et. al. (2017). For the sake of concreteness, let me adduce a well-studied diachronic phenomenon, namely the (loss of) fronting of finite verbs in English. In Shakespearean time, two patterns still co-occur as interrogative variants in English, namely (1a,b) and (1c,d):

(1)	a. *Knows* he not thy voice?	(All's Well that Ends Well: IV, i)
	b. *Lies* he not bed-rid?	(The Winter's Tale: IV, iv)
	c. *Did* he not *send* you twain?	(Love's Labour's Lost: V, ii)
	d. *Did* he not *moralize* this spectacle?	(As You Like It: II, i)

The clause-initial position in questions could either be occupied by a fronted finite verb (1a,b) or by a dummy auxiliary, namely "*do*" (1c,d).[26] In present-day English, main verbs are not fronted anymore. This rules out (1a,b). According to Ellegård (1953:162), the change covered a time span of roughly four centuries (see Figure 1). A detailed discussion follows in subsection 3.4.

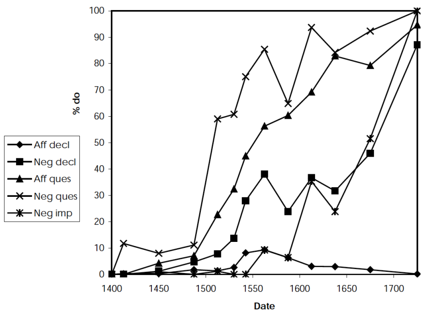

Figure1: Percentage of dummy *do* by sentence type (Ellegård 1953:162)

The *do*-variant gained momentum in early Modern English (starting about 1500). Then, the frequency of *do* in questions and in negative declaratives rises continuously until *do* is obligatory in these contexts in the early 19th century. In the first period, the grammar variant with *obligatory do*-support is a minority variant, but it is compatible with the majority since it generates a subset of structures that are also generated by the grammar of the majority, in which

[25] "*An allele is a variant form of a gene. Some genes have a variety of different forms, which are located at the same position, or genetic locus, on a chromosome.*" https://www.nature.com/scitable/. Different alleles may result in different observable traits. In the context of grammar, roughly speaking, an allele is any procedural or structural grammar condition that is responsible for an (atomic) grammatical property

[26] This is still the present day-situation in German in the areas with Bavarian dialectal substrates, that is, Southern Germany (except for the Alemannian area) and Austria (see Brinckmann & Bubenhofer 2012). In child-directed speech, the do-variant is very frequent, both in V2-declaratives and questions (Nesensohn 2012). The advantage for the grammar-acquiring child is obvious. The child needs to memorize only the morphological paradigm of *tun* (do). The main verbs stay infinitival.

do-support is optional. In the final period of the change, speakers with optional do-support are the shrinking minority. The viral grammar they use is about to die out.

If such a development is a result of adaptive natural selection operating on grammars as cognitive entities, a grammar variant with *do*-support must be shown to offer some advantage under selection. This selection advantage should become effective in first language acquisition as well as in processing. What is the advantage of a stationary main verb in comparison with variants with alternating verb positions? If the head of the VP is stationary and non-portable, it is easy to identify and to predict. No filler-gap relation needs to be computed. Instead, a dummy auxiliary is placed in positions that formerly have been accessible to any finite verb, that is, main verb or auxiliary. Second, the finiteness morphology needs to be activated only for *do*. The main verb appears in its infinitival form. In evolutionary terms, the change that led to *do*-support is a change in which one of two 'grammar alleles', namely a grammar with a specific restriction on the class of verbs that are subject to the rules of fronting has prevailed.

Having illustrated how in principle potential homologues of genetic alleles may look like in the context of grammar, let us return to the crucial issue for Darwinian evolution by selection, namely the *retention* of selected variants. In the exemplary case above, the steady development, starting from nearly zero at about 1400 and reaching the 100% level half a millennium later, is the reflex of a *constant* expansion of the grammar variant with *do*-support. In other words, the grammar variant with *do*-support is retained in the population for generations and gradually spreads, although it once started as a minority variant. What is the mechanism that guarantees retention? It must be a fairly rigid property that cannot be reset or undone easily.

In biology, the mechanism is genetic inheritance. The genome we are born with is the genome we die with. In the case of the cognitive representation of grammars, the rigid property is not genetic inheritance. It is a combination of the *inertia* of *procedurally* coded systems and their conservation due to the loss of plasticity during brain maturation in childhood. The rigid property of grammar is a reflex of its procedural quality: "*Procedural memory is formed more slowly than declarative memory. The other side of the coin is that procedural memory is more robust so that, once formed, it is better preserved, and it is also inflexible, and therefore difficult to change*." (Lee 2004: 69).

Our language capacities depend on two different neuro-cognitive systems, the procedural and the declarative system (Ullman 2001). The declarative system is the general purpose memory system. Its content is consciously accessible and easily rewriteable. Procedurally organized systems, on the other hand, are encapsulated and therefore consciously inaccessible. They are difficult to rewrite and therefore change resistant to a large extent.

As for grammar acquisition, psycholinguists agree that that there is a window of opportunity (Paradis 2009, Morgan-Short & Ullman 2011). It closes in the course of neuro-physiological processes of synaptic pruning and myelinisation on the one hand, and the stabilization of the processing networks by inhibitory regulations on the other hand (Voss et. al 2017). In sum, this accounts for the significant loss of plasticity of the brain for grammar acquisition. The available evidence points to the conclusion that the *procedural* components of the syntactic knowledge systems are efficiently compiled within a sensitive period that terminates around the age of eight years. It is this ensemble of procedures that is change-resistant to a sufficiently high degree for the rest of the linguistic life of an individual.

Here are two examples for the discrimination of *procedurally* vs. *declaratively* stored information, namely verb morphology and case assignment. Irregular verb forms are stored *declaratively*. *Declaratively* stored information is information about *particular* items. It can be changed easily and a change may rapidly spread in the population (see the discussion in sect. 3.4). Case *assignment* on the other hand, is a *procedurally* represented information. A case relation is not an individual property of an item. It is a complex relation between noun phrases, case-governing grammatical items and structural relations between them. The two variants of the causative middle construction in German in (2) are fully synonymous and exchangeable in communication. Nevertheless, the case that has to be assigned to the object of the infinitival verb is different in each configuration in (2). Native speakers are not aware of the principles that govern the distribution of accusative and nominative in these and other structures. Their competence is a reflex of procedurally stored information.

(2) a. Hier ließ sich der/*den Sommer genießen.
here let REFL $\text{the}_{\text{Nom}}/\text{the}_{\text{Acc}}$ the summer enjoy
'Here it was possible to enjoy the summer'
b. Hier ließ *es* sich den/*der Sommer genießen.
here let *it* REFL $\text{the}_{\text{Acc}}/\text{the}_{\text{Nom}}$ summer enjoy
'Here it was possible to enjoy the summer'

A change of a procedurally coded grammatical property is a change in a system that is not open for conscious interventions. If such a system changes, it changes like other complex systems change, namely in the ways channelled by Darwinian evolution. There is variation, there is selection, and if competing variants are sieved out by selection, there will be a variant that continuously spreads. Eventually, it may turn out that it is the only remaining variant. In this case, observers will testify that a grammatical change has been completed. The shared properties of such diachronically attested phenomena are directionality, persistence and a sufficient time span.

Let me emphasize that the distinction between procedurally and declaratively stored and processed grammatical information is not congruent with the distinction between syntactic vs. lexical. What linguists understand as 'lexical' is not synonymous with declaratively stored information. The lexical category of a morpheme is stored with the morpheme, but the syntactic properties of the whole class of items of the very category is not stored with the individual items. The two dichotomies are partially orthogonal. Here is an illustration. Details will be discussed in sect.4.

An example of major and cross-linguistically pervasive syntactic changes is the change from SOV to SVO (Gell-Mann and Ruhlen (2011). Many VO languages have an OV history. Superficially, this change can be described as a change from head-final to head-initial. The converse is virtually inexistent. In the absence of external interference, no language similar to English has ever changed into a language similar to Pashto, that is, from case-less VO into inflectionally case-coding OV. The unidirectionality and irreversibility of this change is the irreversibility of a change from primarily declarative coding of grammatical relations (e.g. by means of morphological markers) to a system with primarily structural coding, which rests on a procedurally-based capacity.

With respect to lexical vs. syntactical change, Generative theorizing favours a conjecture – viz. the Chomsky-Borer-Conjecture (Biberauer & Walkden 2015: 2-3) – according to which all changes that have been traditionally described as syntactic are "*simply lexical*" changes (i.e. changes in the formal features of lexical items). This conjecture is either empirically inadequate or a misnomer, or both. It is empirically inadequate, if a change in the clausal organization with systematic collateral effects for a wide range of syntactic properties, such as the change from SOV to an SVO clause structure, is attributed to a change of lexically stored contents; see Haider (2015b). There is no change in the content of verbs that accounts for the split between OV and VO Germanic. It is a misnomer if a syntactic property of a syntactically defined class of lexical items (i.e. directionality of licensing) is labelled as "lexical information". Directionality is a procedurally operative property and it is not specific to individual lexical items.[27] Trivially, a linguistic expression consists of lexical items. Hence, any syntactic property is ultimately also describable as a property of these lexical items. But of course, this is no legitimation for calling syntactical properties "lexical" in general. The Chomsky-Borer-Conjecture stretches and thereby blurs the concept of "lexical", without explanatory gains. It obliterates the important distinction between *lexically stored, cross-lexically variable content* of a lexical item on the one hand and *procedurally implemented syntactic properties of whole classes* of lexical items on the other hand.

3.2 Darwinian cognitive evolution operates on *processes* and *structures*, not on *content.*

Since Darwinian (cognitive) evolution operates whenever the following preconditions are met – and cognitively represented grammars meet these conditions – grammars are subject to selection and therefore to Darwinian evolution by selection:

- A self-reproducing (cognitive) system
- generating a pool of (cognitive) variants
- in a selective (cognitive) environment for (cognitive) reproduction
- and a mechanism of (cognitive) retention of selected variants.

There is no denying that grammars are complex cognitively represented systems. The capacity of language processing is to a large extent domain specific. This shows in double dissociations. Grammar may be spared when general cognition is significantly impaired. On the other hand, grammatical capacities may be impaired while general cognitive capacities are unimpaired.

The cognitively represented program for processing a specific language is self-reproducing, in cycles of output-input-output. The output controlled by a grammar serves as input for the acquisition of this grammar by others, who produce output which is input for others, and so on. The transmission process generates variation, and the pool of variations is fed by external factors, too, for instance by intensive language contacts (cf. "gene flow").

[27] An exception is instructive at this point. In every Germanic language, the cognate of "*enough*" is exceptional, since it follows the item it modifies, instead of preceding it (Haider 2013:68). Thus, a syntactic information is stored as part of the lexical content of an individual lexical item. However, this is not the way, how linearization information is grammatically coded in general.

Grammar in use is first of all a skill-type capacity, that is, it is part of the procedural networks. These systems are inaccessible to conscious interventions and subject to processes of brain maturation that stabilize it. Its effective functioning also involves a network of inhibitory effects. These properties divorce it from declaratively stored grammatical information, such as the lexical and morpho-syntactic inventory of a language. The latter can be volatile. During the whole life time, it is easy to amend and it is easy to add or replace lexical items by others within a short period by social learning.

The acquisition and cognitive representation of grammar is embedded in, and sustained by, domain-general cognitive capacities. In IT terminology, the domain-general capacities constitute the operating system. A grammar is an app or co-processor that runs on this cognitive computation platform. The general capacities determine whether a grammatical variant is 'easier' to acquire or carry out than other variants. In sum, this amounts to a constant selection environment for grammatical variants.

These factors taken together are sufficient for triggering natural selection. However, the selection processes operating on a pool of variants of a cognitively represented and self-reproductive system can result in a grammatical change only if selection finds enough time for becoming effective. So, the variants must be *preserved* in the pool of variants. Natural selection cannot cope with moving targets. Retainable variants are procedurally coded elements of grammar that are entrenched during the sensitive period(s) of first language acquisition. This guarantees retention.

Second, evolution is a slow process and adaptive mutations are selected over periods of many generations before they reach a critical level of sustainability in the population. Bell & Gonzalez (2011) studied biological evolution by selection in real time[28] under lab-conditions and found out that adaptive changes may happen surprisingly fast even for biological system, namely within 50 generations. In biology, "one generation" is one reproduction cycle. For language change, one reproduction cycle is one acquisition-to-production cycle, that is the period from the start of first-language acquisition until the production of output that may serve as continuous input for others who acquire the language. Conservatively estimated, this is a period of roughly ten years.[29] Hence 50 generations would mean approximately 500 years. This is a time span for grammar changes that is compatible with time spans found by diachronic studies.

3.4 Naturally selected vs. drifting.

Genetic drift is random, selection is vectored since the processes of sieving out variants are constant. With respect to drift, the variants in one generation do not reproduce in equal ratios in the next generation. The linguistic literature on language change focuses on phenomenological properties and does not primarily study them in terms of their *evolutionary* history. Changes may be random (= drift) or channelled by natural selection, and one may be mistaken for the

[28] They submitted yeast populations to varying degrees of environmental stress conditions in order to study evolutionary reactions, which is the ability of a population to adapt rapidly through evolution. (McGill University: *Science Daily*, 23 June 2011. <www.sciencedaily.com/releases/2011/06/110622115311.htm>.

[29] The reproduction cycle for language must not be confounded with the concept of "generation" in social sciences (i.e. 25-30 years) since siblings (brothers, sisters, cousins) are effective generators of language input. Bridges & Hoff (2014) found that toddlers with older siblings were more advanced in English language development. Even overheard speech between siblings and parents has a positive effect; cf. Oshima-Takane et al. (1996).

other. In biology, and in particular in population genetics, methods have been developed for identifying the character of changes and for differentiating among them. Linguists typically conjecture potential causalities but do not thoroughly test their hypothesis with such methods because they are still alien to their field.

In the past decade, however, linguists have joined forces with biologists in teams with the mix of competences necessary for tackling such issues. Newberry et al. (2017) apply an analytical technique which tests against random drift as the null hypothesis. The technique[30] has been developed in population genetics for discovering the effect of natural selection in microbial populations. It will become clear in the following discussion that a successful transfer of a technique does not automatically transfer the appropriate interpretation of the results. Newberry et als (2017) claim to have identified selection-effects. They claim to have identified instances of 'non-neutral drift', that is, changes with an effect on the 'phenotype', that is, the language in use. The variants are not mere stochastic noise. This is true, but the conclusion is wrong, since the first premise of their inference is not true in the linguistic setting: Either drift or natural selection, hence if not drift, then natural selection. What they fail to appreciate is the interfering third case, namely non-evolutionary, socially geared changes in the declarative inventory. Half of their study focuses exactly on such a property, namely tense morphology. In all, their study is instructive since it contains both, a change in the *declarative* domain of grammar (tense morphology), and a change in the *procedural* component (Aux-placement). They adduce diachronic corpora of English and study two different areas of change, namely the diachronic dynamics of past tense forms (regular – irregular), and the development of *do*-support. For their analysis of morphological changes in past tense formation, they track thirty-six verbs in the 400-million-word corpus of historical American English (CohA), which covers the period of 1810s-2000s. As for *do*-support, they use three parsed corpora.[31]

The interpretation of the result of their investigation of past tense forms of 36 verbs is amazing since their method does not legitimate it: "*For six of these verbs we can reject neutral drift*[32] *for all population sizes N, with nominal p < 0.05. Contrary to the standard linguistic expectation, in four of these cases we infer selection towards the irregular variant* (*dived→ dove, waked→ woke, lighted→ lit, sneaked→ snuck*), *whereas only two cases exhibit regularization* (*wove→ weaved, smelt→ smelled*)." Figure (2a) is Newberry's (et al. 2017) figure #2. Figure (2b) is a plot from Masel's (2011: R837) explication of the *drift* of alleles. The graphs look alike, although (2a) plots the subset of verbs that are claimed to testify against drift and for selection.

The method of analysis applied by Newberry et. als (2017) tests *against* 'neutral drift', that is, random changes without *phenotypic* alterations. "*The frequency increment test (FIT) rejects neutrality if the distribution of normalized allele-frequency increments exhibits a mean that deviates significantly from zero*." (Feder 2014: 509). The test is not designed for a positive identification of (natural) selection but only for ruling out the null hypothesis, namely random

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30 *Frequency Increment Test*, as developed by Feder et. als. (2014), based on the standard χ^2 test.

31 York-Helsinki Parsed Corpus of Early English Correspondence (1400-1700), the Penn-Helsinki Parsed Corpus of Early Modern English (1500-1700), and the Penn Parsed Corpus of Modern British English (1710-1910).

32 "Neutral drift is the process of change of genotypes by random genetic drift without phenotypic alteration in evolution. It occurs when many genotypes give rise to the same phenotype. In such cases, genotype may change within a given phenotype." https://www.sciencedirect.com/topics/nursing-and-health-professions/genetic-drift.

drift. This is sufficient in a situation of a (nearly) *dichotomic* partitioning of drift and natural selection.

Figure 2a: Newberry et al. 2017.

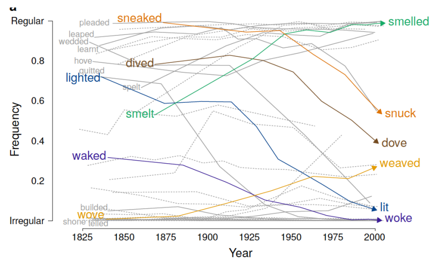
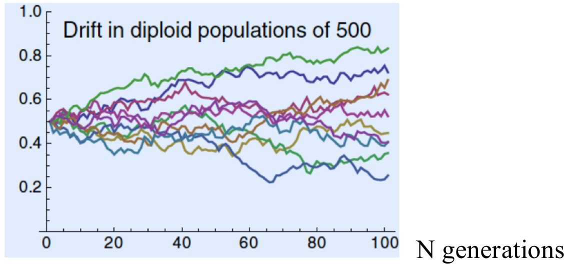


Figure 2b: drift (Masel 2011: R837)



For language change, the situation is not dichotomic. In language use, it cannot be excluded that other factors (e.g. socially-based preferences) influence the choice of a particular past tense form in such a way that the mean of frequency increments deviates from zero. Karjus et al. (2020), who replicate the analysis, point out "*that care should be exercised with interpreting results of tests like the Frequency Increment Test on individual series, given the researchers' degrees of freedom available when applying the test to corpus data, and fundamental differences between genetic and linguistic data.*"

The list of six verbs[33] suspected to be testimonies of (natural) selection, is evidently an inconsistent set. Selection is claimed to have led to opposite outcomes, namely irregular forms as well as regular forms. The 200 years documented by the corpus they use, namely CohA, are not representative since the alternation between 'weak' (= regular) and 'strong' (= irregular) forms can be traced back to the Old English period for many of these verbs.[34] Since then (Peters 2004: 293), "*the number of verbs reverting to the regular pattern is much larger than that going the other way. This opposite process can however be seen with hang and sneak (for both past forms)*." "*Dove*" is the exception since it is a singularity. It is a regional innovation, dating back to the 19th century. Outside of North America, the past tense is "*dived*". Figures (3a,b) document search results of the Google nGram-online-viewer [March 23, 2020], restricted to American English books in (3a) and British English books in (3b). It confirms the CocA-based findings.

Figure (3a) shows that the frequency of "*He dove*" steadily increases in the US. It exceeds the frequency of "*He dived*" in the period after 1980. "*It smelled*" is preferred over "*It smelt*" already since a century in the US, while in the UK the lines cross in the sixties. "*Smelled*" is the regular form, "dove" is an irregular one. Both directions of change are attested, and in each case, both forms still co-exist.

Figure (3a): *he dove* – *it smelled* (USA)

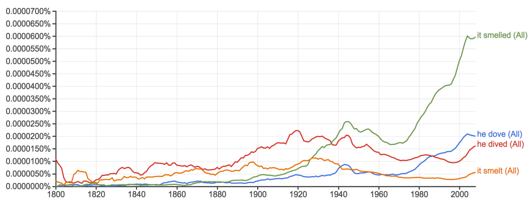
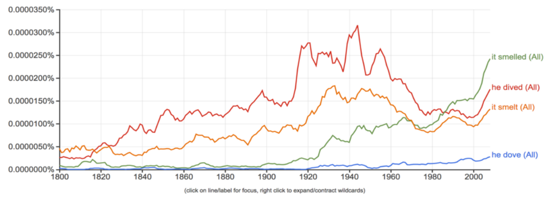


Figure (3b): he dove – *it smelled* (UK)



[33] "*Six of these verbs experience selection for either regularization or irregularization*."

[34] Verbs have individual histories: The alternation between *cleave-cleft-cleft* and *cleave-clove-cloven*, for instance, is a reflex of the time when there existed two homonymous verbs *'cleave'* (Peters 2004:108). The same is true for *'hang'*, with *'hanged'* for execution by hanging, and 'hung' for 'suspended', in the original usage.

Analogous processes can be documented in any language with regular and irregular verb forms, as for instance in German, with the result of a Google nGram search displayed in Figure 4.

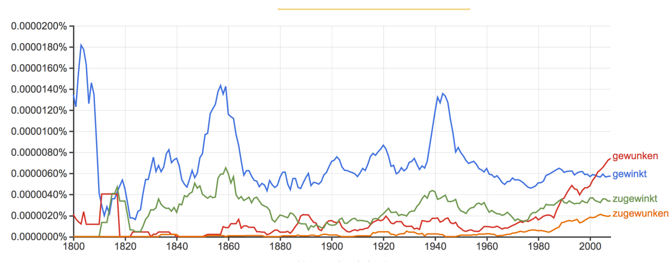


Figure 4: Frequency increase of *'gewunken'*, the irregular past German participle of *'winken'* (to wave).

Note that the participle form of the particle verb *'zu-winken'* (wave to sb.) does not dodge the change of its base form '*winken*' since *'zu-gewinkt'* remains more frequent than *'zu-gewunken*'. Once more, the change is specific of a particular item, namely *'winken'*[35] and does not generalize.

Fluctuation between alternative tense forms across verbs is an indicator of random variation. It is not a change of a grammatical '*rule'* but only a change of token frequencies of the *inventory*. One form is replaced by another for a particular verb. "*Dove*" is shaped in analogy to a highly frequent and phonetically close verb, namely *"drive – drove*" (in a subclass with less frequent verbs such as *strive, thrive, or arise*), but crucially, without joining the whole paradigm, that is, *dive – dove – *diven*. The form *'dived'* continues to be used as the past participle form. This shows that the switch to "*dove*" is not a rule-based switch in the paradigm of a verb. The converse change – irregular-to-regular – associates the verb with a morphological rule, as in the case of "*smell*": smell – smelled – smelled vs. smell – smelt – smelt. CohA lists only six tokens of "*has smelt*" between 1860 and 1960, and nothing thereafter.

Past tense morphology is an example of a persisting change over the last millennium of English that associates forms with rules rather than individually stored information per verb. Standardization and schooling is an antagonistic force. This shows especially in less formal situations, as reported by Gray et al. (2018), who adduced a large corpus of Twitter-data.[36] The analysis of the geo-tagged data per county reveals a distinct East-West slope in the US. "*In general, western counties show less regularization than average and eastern counties show more, except that the New England area is fairly neutral.*" (Gray et al. 2018).

A final remark on the *dive-dove* case: It highlights a familiar trade-off relation between storage and rule-application. For highly frequent forms, the cost-benefit-ratio favours storage of individual forms over rule-based formation on demand.[37] On the other hand, rule-driven formation saves storage costs since per word, in the simplest case, only the lemma needs to be stored. For highly frequent forms, the cost of individual storage is less than the cost of frequent activations of a rule. The cost-benefit ratio is the storage cost of the separate forms of an item in comparison with the cost of rule activation multiplied by the (average) number of activations. Associating

[35] Note furthermore, that a *paradigm* like *winken – winkte – gewunken*, that is, regular past tense but irregular participle does not exist. The model is *trinken* (drink) – *trank* (drank) – *getrunken* (drunk). The analogous form *"wank*" is not attested for *winken*, only for *wanken* (stagger).

[36] Their study focuses exclusively on regularization.

[37] The 18th century physicist Georg Christoph Lichtenberg noted that the most frequently used verbs are the most irregular ones in all languages: *„Diejenigen Verba, welche die Leute täglich im Munde führen, sind in allen Sprachen die irregulärsten; sum, sono, ειμι, ich bin, je suis, jag är, I am.“*

a form of a verb with a frequent form of related verbs amounts to a free-ride effect on the sub-regularity.

Let us turn now to a structure-based change, namely the development of *do*-support in English, which took place in the time between the fifteenth and the nineteenth century. In the original caption of Figure (5), the authors comment that the use of *'do'* as an auxiliary verb first arose in the context of interrogative sentences (grey). Drift could be excluded neither for affirmative nor for negative interrogatives. Subsequently, the frequency of *do*-support rose rapidly in negative declarative and negative imperative sentences, wat they interpret as a result of selection.

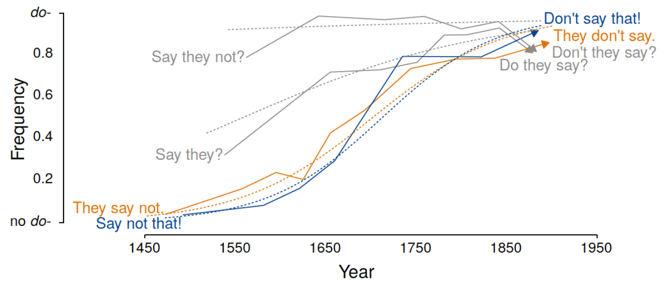


Figure 5: (= figure 3 of Newberry et. als 2017): frequency increase of *do*-support.

In an interview,[38] one of the authors, Plotkin, summarizes their findings: "*It seems that, once 'do' was introduced in interrogative phrases, it randomly drifted to higher and higher frequency over time. Then, once it became dominant in the question context, it was selected for in other contexts, the imperative and declarative, probably for reasons of grammatical consistency or cognitive ease.*"

What this quote describes is the spread of a grammar variant after a period of free variation. In this phase, a grammar variant gets momentum when the main verb in English is fixed to its base position. It is not fronted anymore to the clause initial position in questions, and subsequently it is not fronted anymore across negation to the position that in present day English, is open only for finite auxiliaries and quasi-auxiliaries. In the middle of the nineteenth century, finally, the grammar variant has successfully 'infected' the whole population.

Within Germanic languages, English *do*-support is an isolated peak in the evolutionary fitness landscape, in Wright's (1932) terminology. No other Germanic language has grammaticalized a do-periphrasis.[39] Why not? Because the momentum of selection is just a nudge but not a compelling force. This is fully parallel to biological evolution. Generally, evolution is diversifying rather than unitizing, since it is fed by random variation.

The computational advantage of *do*-support is evident. Main verbs end up as fixed in a unique structural position, namely the head-position of the verb phrase. No filler-gap dependency needs to be computed for verbal heads since the secondary positions for finite verbs are the domain of finite auxiliaries and the dummy auxiliary *'do'*. The 'price' for the advantage of a

[38] https://penntoday.upenn.edu/news/luck-plays-role-how-language-evolves-penn-team-finds

[39] It is a textbook example of the grammaticalization of a variation attested in numerous languages; see Cornips (1998) or Jäger (2006), who describes the phenomenon of periphrastic '*do*'-constructions in a sample of two hundred languages.

predictable and invariant structural position of the main verb is the recruiting of a dummy auxiliary for the structures in which a finite verb is required in a fronted position.[40]

In Generative-Grammar terms, the change in English started when the use of *'do'* began to be construed as an indication that the finite verb must not be fronted to the clause initial functional head position. Within a comparatively short period, the grammatical consequences triggered by the consistent implementation of this change become visible: If the finite main verb is not fronted to the clause-initial functional head position, it cannot be fronted to the clause-medial functional head position (i.e. tense and agreement) either, because the two positions are automatically connected. A finite verb in the lower position is the candidates for the higher position in interrogative constructions. Consequently, *do*-support becomes grammatically mandatory for negated sentences as well. What figure 5 reflects is the initial co-existence of grammar variants, most of which have been sieved out within roughly twenty five linguistic generations.

4. Natural selection or social change, or both

Language is a neuro-cognitive as well as a social and cultural phenomenon. The neuro-cognitive side is the domain of Darwinian selection; the social side is the domain of social change of cultural symbols, rules of behaviour, or value systems. In language change, clear instances of each of these factors can be identified, and often, both kinds of changes are at work simultaneously, see Table (1).

Table 1: D-selected (Darwinian selection) vs. socially motivated

	+ D-selected	– D-selected
+ socially motivated	Darwinian & social change	social change
– socially motivated	Darwinian change	others: flow & drift

In the case of language, differentiating between the respective domains requires at least two combined criteria, namely the *time course* and the *declarative/procedural* basis of a change. Social changes are *rapid*, and they involve *accessible* properties, that is, items of the inventory. Changes based on natural selection concern the *procedural* organization and are slower, that is their spread and implementation takes much more time. Declaratively stored content comprises not only the lexicon but also the morpho-syntactic inventory, including affixes, pronouns, particles, etc. The latter items are tightly governed by rules of grammar and therefore more change resistant. The general vocabulary, can be (ex-)changed or augmented easily during the life-time of a speaker. However, a *specific* subset of the vocabulary – the so-called basic vocabulary – is fairly stable across a community and over time.[41] This has recently been confirmed in the study of 81 languages of the Pacific area, by Greenhill et. al. (2017: E8822), who employ 210 items of basic vocabulary and 157 grammatical features: "*We show that, on average, most grammatical features actually change faster than items of basic vocabulary.*" The emphasis is on 'basic'. Vocabulary changes (by extension or replacement) fast, but a subset of it, namely the early

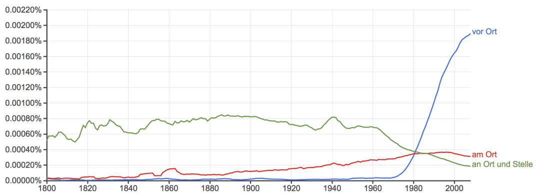
[40] If this is an advantage indeed, it should not pose problems during language acquisition, and it does not. In a corpus study, Stromswold (1990) found that on average, the age of the first use of the auxiliary *be* is 2;7, followed by do-support at 2;8 while auxiliary *have* is the last. See also Rispoli et al. (2012) for similar findings.

[41] "Basic vocabulary", as defined by Collins on-line dictionary: "*The set of lexical items in a language that are most resistant to replacement.*"

acquired basic vocabulary is conservative. Such finding replicate results known from Indo-European studies. Present day Indo-European languages widely differ in their structures and morpho-syntax, but still share a large amount of their (phonetically transformed) basic vocabulary. The reason for this seems obvious. Basic vocabulary is acquired very early in childhood and it is highly frequent in use (see Vermeer 2001). This stabilizes and conserves it.

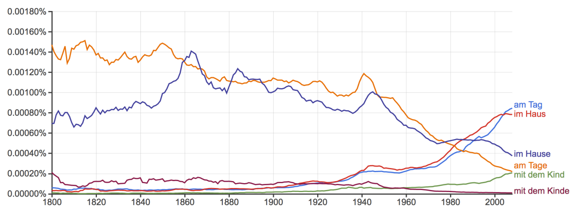
What follows are three illustrations of differences between social changes and changes by selection. The plots are Google NGram search results of book corpora from March 2020. The changes depicted in Figure (6a,b) are social changes. In German, "*am Ort*" (*at*-the location) recently gets replaced by "*vor Ort*"[42] (lit. *before* location), and *Fakt"* ('fact') is preferred over "*Faktum*" (Latin loan), especially in the frequent expression "*Faktum ist*" (*fact is* ... = 'It is a fact, ...'). These are rapid, item-based changes that have become effective within approximately two decades. This is characteristic of the socially motivated expansion of 'trendy' expressions in a language community.

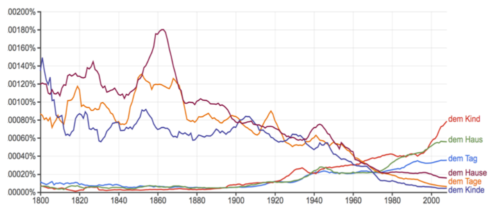
Figure (6): a. "*am Ort*" → "*vor Ort*"[43] b. "*Faktum ist*" → "*Fakt ist*"



The second example is a change in case marking morphology of datives. The ending "-*e*", which dates back to Middle-High-German, is cancelled. The change becomes manifest only after the middle of the 20th century, a reason being that until then, schooling enforced a norm with the Dative ending.[44] This is a rule-based change antagonised by a social factor, namely the normative force of schooling.

Figure (7): Dative with "-e" → without "-e"





(glosses: *am Tag*: at-the day; *im Haus*: in-the house, *mit dem* Kind: with the child; *dem*: Dative def. article)

The third example is the "*as A as Y*" construction (e.g.: *as fast as Y*) in German (Figure 8). In present day German, the preferred version is "*so* A *wie* Y" (lit.: so A how Y"). "*Wie*" (*how*) replaces "*als*" (as, than), that is, "*so schnell als*" (as fast as) is supplanted by "*so schnell wie*" (lit.: as fast how).

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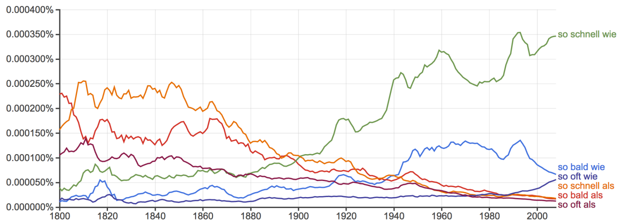
[42] Originally, this is a technical term of mining, meaning that the tunnelling has arrived at a spot "immediately *before* the ore deposition", but not yet "*at* the deposition". Vernacular usage treats the terms as synonymous and *'vor Ort*' as the prestigious, because more professionally sounding, variant.

[43] "*An Ort und Stelle*" (lit.: at place and spot) is a common idiomatic expression.

[44] e.g.: *Schulgrammatik des Deutschen* (= school grammar of German), by Karl F. Becker, 1845, p. 126, §136, Frankfurt: Verlag von G.F. Kettembeil.

Figure 8: German: "*so* A *als*" → "*so* A *wie*"



so schnell ***wie*** – so fast as
so bald ***wie*** – so soon as
so oft ***wie*** – so often as
schnell **als** – so fast than
so bald **als** – so soon as
so oft **als** – so often as

What looks like a simple replacement of "*als*"(as) by "*wie*"(how) is in fact a more complex change consisting of structure reduction plus subsequent integration in the wider grammatical fabric.[45] The constructions "*so A wie*" and "so A *als*" are continuations of "so A *als wie*"[46] (so A *as how*), which is reduced by dropping either "als" or "wie", resulting in two competing variants. The "*als wie*"-variant is still attested in Southern German vernacular, since it is a regular variant in Bavarian dialects (s. Merkle 1975: 171). Although such a change is a plausible candidate for a selection effect, at least for the first step, that is the reduction of structure, it is still open for social influence, such as normative regulations in schooling: "Combine *so* with *wie,* and comparatives with *als!*"

Let us turn now to clear cases on the other side of the spectrum, namely clear cases of natural selection operating on the cognitively represented grammar systems. A century ago, Sapir (1921:174, 177, 180) has identified three grammatical 'megatrends', namely the "drift" to fixed position, the drift to the levelling[47] between the subject and the object, and the drift toward the invariant word. These three processes are entangled.[48] These are changes that on the one hand, *shift the working load* from the declarative to the *procedural* network in production and reception and on the other hand enhance *predictability* in parsing (Levy 2008).

The "drift" to fixed position is a "drift" towards head-initial phrases and an [S[VO]] clause structure. In this structural constellation, each item is uniquely defined by its structural position. As a consequence, morphological markings for grammatical functions such as subject, object or indirect objects become redundant and can be reduced. The result is a language with fixed word order, levelled subject-object relations (= "neutral alignment" in typological terms) and invariant rather than inflected nouns and verbs.

This scenario is well-documented in the history of languages and in particular in the history of Germanic languages. Siewierska (1996), in a study based on a sample of 237 languages, notes that "*in line with common assumptions, neutral alignment in V2 languages is more frequent than in any other word order type; it occurs in just over two-thirds of the V2 languages in the sample*". "*Neutral alignment*" is the term for "no morphological case distinction" between subject and object, and "V2" is her idiosyncratic term for grouping together SVO and OVS.[49] In

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45 Direct replacement of "*als*" by "*wie*" would be a change between incongruent categories, since "als" is a preposition and "*wie"* is a wh-pronoun.
46 Goethe (Faust): "und bin so klug *als wie* zuvor" [and (I) am so wise *as how* before]
47 "levelling between subject and object" = abolition of morphological case distinctions (s. Sapir 1921:714)
48 "*The drift toward the abolition of most case distinctions and the correlative drift toward position as an all-important grammatical method are accompanied, in a sense dominated, by the last of the three major drifts that I have referred to. This is the drift toward the invariable word.*" (Sapir 1921:180).
49 "OVS" is a very infrequent type. In fact, it is "SVO" with an Ergative-Abs case-system (e.g. Pari, Jur Luo, Hishkaryana, Asurini, Oiampi). Since typologists tend to identify "O" semantically, that is, by the "patient" role, they fail to properly appreciate the fact, that in an Abs Erg- system, the "patient" is the structural *subject*.

reality, the correlation between SVO and case-less languages is much higher since typological surveys classify languages merely by *preferred* linearization patterns, irrespective of their clause-structure. As a consequence, many languages are (mis-)classified as SVO which are structurally not [S[VO]]; see for instance the supplement[50] to Gell-Mann & Ruhlen (2011). Slavic languages, for instance, are (mis)classified as SVO (s. Haider & Szusich 2019) and known for their rich morphological case marking (except for South Slavic languages, such as Bulgarian and Macedonian).

What is the cognitive and therefore selectively effective bonus of structural coding? In an [S[VO]] language, grammatical relations are *structurally* defined. This means that there is a *single* rule for covering the clause structure of any clausal utterance. In declaratively coding languages, there are typically a number of different morphological paradigms for a single grammatical function as for instance a subject or a direct object. This entails a lot of declaratively stored morphological information as well as hardly any chance of a safe prediction of what item will come next while parsing the preceding item of an utterance. Structural coding not only reduces the amount of information involved in the identification of grammatical relations. The strict linear order restrictions greatly enhance the accuracy of look-ahead predictions in on-line parsing and thereby enhance its efficiency.

In [S[VO], the (obligatorily lexicalized) preverbal argument position is structurally identified as the subject position, followed by the verb, followed by the indirect object and the direct object, without any intervening material between the verb and its objects (3a). The grammatical relation of a given noun phrase is identified by a rule that maps linear order on a structure. Note, however, that structural coding is an evolutionary result. It is the continuation and overcoming of declarative coding and it presupposes the existence of lexical categories.[51]

In a relationally coding language (3c), grammatical relations of noun phrases are identified by their morphological shape and they are freely ordered, as for instance in German (3d) or Polish (3e). In languages that identify noun phrases by their morphological case, the acquisition of case morphology and the actual identification is an arduous task, as everyone knows who has acquired such a language after childhood. It usually requires a lot of cross-linking of declaratively stored information that needs to be memorized.

(3) a. ..... [subject [verb$_{fin.}$ object$_1$ [object$_2$ .....]]] structurally coded
b. that someone envies someone something
c. ..... [.... subject$_{Nom}$ ... object$_{Dat}$ ... object$_{Acc}$... verb$_{fin.}$] relationally coded

As the structural subject, it precedes the verb in an SVO clause structure. An ergative "OVS"-language like Hurrian or Kuikuró is in fact an SVO language, modulo ergative alignment. Erg-V-Abs languages do not exist.

50 http://www.pnas.org/content/suppl/2011/10/04/1113716108.DCSupplemental/sapp.pdf. Afrikaans, Frisian, German, and Luxemburgish are listed as SVO, although all these languages are [SOV & V2]-languages, just like Dutch, which is filed as "SOV/SVO". Except for Sorbian, all Slavic languages are listed as SVO, although no Slavic languages shares the syntactic properties of structural SVO languages, except for the S-V-O linearization as one of many grammatical serialization variants in these languages (see Haider & Szusich 2019).

51 Salish languages (Jelinek & Demers 1994) are testimonials of what appears to be a design that antedates the design of the classical Indo-European languages. In Salish languages, lexical categories are in existent. The arguments of a lexical item are differentiated by morphological markers, not by lexical category or by phrase structure. As a consequence, „*Salish languages are as close to 1st order predicate logic as natural languages get*.“ Cable (2008).

d. dass dem Mann$_{Dat}$ das Problem$_{Akk}$ jemand$_{Nom}$ erklären muss (German)
dass the man the problem someone explain seized

e. że mężczyźnie$_{Dat}$ dom$_{Acc}$ pokazał Jacek$_{Nom}$ (Polish)
that (to) man house showed Jacek

The order in (3e) is one of 24 *grammatically* admissible orders[52] of four elements in Polish and in other Slavic languages. In addition to the free relative order of the arguments, the verb may appear in any of the four possible positions after the complementizer. Hence, linear order does not provide reliable cues for alignment and for the prediction of the next item to be parsed.

The crucial gain of structural coding is the purely structural implementation of alignment. If a grammatical rule changes a relation, as in the case of passive, the structural position changes as well. This gain is high enough for lifting an [S[VO]] grammar into a very stable state. The inverse route, i.e. an SVO languages changing into another type, is not attested, as Gell-Mann and Ruhlen (2011: 17291, fig.1) claim, based on their broad survey. When a language has attained an [S[VO]] structure, it stays [S[VO]]. No language is known that has started out from a system like English and ended up with a grammar like Sanskrit. Many present-day [S[VO]] languages are known to have been SOV, VSO or free-word-order languages in their past, however.

If the [S[VO]]-architecture is a strong attractor, this means that it is strongly selected. If this is the case, then – in terms of evolution theory – any change that gives up the [S[VO]]-architecture would be a change that reduces the "fitness" of a grammar. This state of affairs is in line with Fisher's (1930) Fundamental Theorem of Natural Selection, which implies that the mean relative fitness of a population cannot decrease during evolution, cf. Orr (2009: 531), Koonin (2011:8). This is a necessary consequence if selection constantly sieves out the less adapted variants. Selection does not eliminate a better adapted variant and therefore the fitness peak reached with an [S[VO]] clausal architecture remains stable.

Typologists acknowledge a trade-off between strict word order and rich morphology. Some languages express argument structure, sentence type and other categories primarily by morphological marking. Other languages use word structure for the same functions. Nichols (1992) produced pioneering work, systematically quantifying morphological complexity in a sample of 200 languages, based on grammatical descriptions. Koplenig et al. (2017) present an analysis based on 1.559 Bible translations in 1.196 languages, in a quantitative information-theoretic approach: "*Languages that rely more strongly on word order information tend to rely less on word structure information and vice versa*".

In a diachronic perspective, the crucial point is that the trade-off is *unidirectional* rather than *bi-directional*. Grammars do not fluctuate between the two poles (= word order only vs. morphology only). The unidirectionality of change from morphology to structure is a consequence of selection. It is the unidirectional change towards [S[VO]] that invites the reduction of morphological marking, and not the loss of morphology that invites the structural change, as Gibson et al. (2019)[53] or Siewierska (1996, fn 1) seem to presuppose: "*The loss of case marking is*

[52] *"In each of the Slavic languages, all twenty-four possible combinations of a subject, direct object, indirect object and verb occur as grammatical declarative orders."* Siewierska & *Uhliřová* (2010:109).

[53] "*If a language has morphology, then it does not need fixed word order*. (Gibson et al. 2019: 390).

typically considered to underlie the change from SOV to SVO order in English, the Scandinavian and the Romance languages." (Siewierska 1996, fn.1). In fact, the trade-off is not the driving momentum (see Bulgarian and Macedonian). The change to structural coding simply makes morphological coding redundant, as Jespersen has emphasized already more than a century ago,[54] but it does not automatically replace it (see Icelandic).

Bulgarian and Macedonian, on the other hand, are languages with the typical free word order of Slavic languages but without nominal case morphology or case particles (Avgustinova 1997, Wahlström 2015). The languages are linguistically closely related to their neighbouring Slavic languages, all of which have preserved their morphology. Nevertheless, they share their clause and phrase structure and concomitant word order freedom. As for Icelandic, this is an [S[VO]] language whose word order restrictions on objects are as strict as in English or Danish (see Dehé 2004:94), in spite of its rich nominal and verbal morphology. The first Icelanders were Norwegian settlers. Modern Norwegian has lost most of its nominal and verbal morphology since this time. Icelandic has preserved its old-to-middle Norse morphology but nevertheless has developed into an SVO language.

What Icelandic confirms, however, is a law of population genetics, namely Fisher's (1930) fundamental theorem: "*The rate of increase in fitness of any organism at any time is equal to its genetic variance in fitness at that time*."[55] In other words, the intensity of selection and hence, the rate of evolutionary change due to selection is proportional to the magnitude of variation in an evolving population, which, in turn, is proportional to the effective population size (Koonin 2011: 7). This accounts for the fact that languages in small populations, such as Icelandic, Faroese, or Logudorese Sardinian, change much less than, for instance, Swedish, Danish (compared to Icelandic), or Italian (compared to Sardinian), although they are offspring of a common ancestor language in each case. A small population confined to a small region produces less variation and therefore less chance for evolutionary change in general.[56] The alleged *pressure for effectivity* would be operating in any language, regardless of the size of its population. In fact, in a smaller community, it could reach every member much faster. Social changes spread fast, changes by natural selection are gradual and relatively slow and they are dependent on an existing pool of variants. In sum, changes towards and within a structurally coding system are Darwinian; social changes are mostly Lamarckian, and the declaratively stored parts of languages are accessible for social changes.

Let me summarize this section with a question. Why are not all languages SVO languages, given that SVO is strongly favoured by selection? Selection is a 'bonus program', not a 'taskmaster'. First, biological evolution shows that fitness landscapes consists of numerous stable, local maxima. Working grammars are local maxima, otherwise they would not be able to 'infect' whole communities. Second, evolution is myopic. There is no bonus for a peak that could only be reached after giving up a comfortable state and cross over uncomfortable terrain. SOV is a comfortable setting (cf. Goldin-Meadow et. als. 2008), and it is structurally less complex than an [S[VO]] clause structure. The processing-bases bonus for SVO is big, but only in hindsight;

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54 Jespersen (1894: §75, 96-97) has explicitly rejected such an idea: "*A fixed word order was the prius, or cause, and grammatical simplification, the posterus, or effect*".

55 Later, Fisher restated it: "*The rate of increase in the average fitness of a population is equal to the genetic variance of fitness of that population*." Li (1964: 505).

56 This setting does not prevent changes but it *reduces* variation and thereby it reduces the of future changes.

it is small for each step on the way to SVO, unless there is an 'enzymatic' interfering factor, as for instance in the split of Germanic languages into SVO and SOV, namely the development of the verb-second property. For details please consult (Haider 2014).

5. Consequences

The focus on particulars of changes must not divert the attention from the general consequences of Darwinian evolution for language change. If grammars are cognitive systems with a Darwinian evolutionary history, that is, a history governed by the interplay of variation & selection, the general characteristics of Darwinian evolution will inevitably have to show as well. These properties separate evolutionary changes from changes with a different aetiology, as for instance socio-cultural alterations (which may nevertheless prepare the ground for Darwinian changes).

i. Evolution eventually leads to *speciation*.
ii. Evolution results in a 'hilly' *adaptive landscape*.
iii. Evolution is *convergent* (because of constant selection in the same environment).
iv. Evolution does not *trigger* changes but *constrains* them.
v. Evolution is often *punctuated* by long periods of little or no change.

Speciation: Darwin's title phrase "*on the origin of species*" points to the long-term outcome of evolution, namely speciation as a consequence of natural selection. If "individual language" is the parallel of "individual species", then dialect split plus the subsequent development into separate languages is a process of speciation, and it happens under the same conditions, namely allopatric (due to geographic isolation), parapatric, or even *sympatric*, that is, *within* a speech community. A particular example is a "*complete linguistic system whose use is determined by the gender affiliation of the speech participants*" (Dunn 2014: 40). Like in biology, a particular variant of a virus is specialized for a particular group of hosts.

Adaptive landscape: The general picture is familiar from biology (Skipper & Dietrich 2012). There are universal properties and there are type-specific ones. Types are clusters of properties that surround a strong attractor. Evolution of grammar accounts for the emergence of different types rather than uniform members of a cross-linguistically universal format of grammars.

Evolution operates on a pool of randomly originating variants. It is not goal-directed. As a consequence, system changes that result from constant selection lead to different types of systems. There is no single universal grammar, but there are universal within-group properties. If grammars evolve in a Darwinian way, there is nevertheless room for linguistic universals. First, there is negative selection, that is, certain properties are always sieved out. The remaining properties are not imposed on languages by a pre-configured "universal grammar"; they unavoidably emerge by negative selection. Such universals are core characteristics any grammar must meet in order to be effectively learnable and processable, given the specific cognitive "system software" a human brain uses for language. Second, there are positively selected properties. These are reflected as typological generalizations. Typological generalization means a type-specific clustering of properties. In evolutionary terms this means that changes are not deterministic since there always are alternative attractors, each one with consequential effects of its own. These different sets of consequential effects of each attractor we perceive as types.

In linguistics, two opposing positions dominate the discussion. On the one hand, diachronic change is explained as switching between options provided by a "Universal grammar" (UG) in the course of imperfect acquisition of grammar. This is the perspective of the Generative school of thought. On the other hand, cross-linguistically recurrent structural patterns in grammar are explained as results of recurrent patterns of change fuelled by communicative needs. This is the position of the functional-typological school of thought. In its consequent form, the program seeks to replace UG and explain cross-linguistic invariants as by-products of language change. In the absence of a theory that explains why certain changes are recurrent while other potential changes are not, this account remains circular,[57] of course.

Already in the title of his paper, Kiparsky (2008) suggests a compromising position, namely "*universals constrain change; change results in typological generalizations*." In his view, "*any structural feature that is caused by change is inherently unstable (vulnerable, as Saussure put it). Therefore, recurrent structural features that are caused by recurrent patterns of change are typological generalizations but not true universals*."

If it were true that changes lead to "*inherently unstable*" states by disturbing the balance of a system, the natural consequence would be that such an unstable system returns to its previous stable state after having oscillated for a while, or to a new stable state, if it passes a break-over margin. In evolution, any self-reproductive system is potentially dynamic. In the absence of a positively selected 'competing' variant, a system is stable and inherently protected by negative selection. Since variation is random and not triggered, changes are not predictable and not organized. Once a beneficial variant appears and is selected, a change is initiated if the variant spreads. The new and the old system are stable in itself, but one gains ground in the community of language-acquiring brains and eventually replaces the previous system.

The difference between universal features and typological generalizations is one between necessary and possible properties. Typological generalizations are correlations that characterize positively selectable constellations of features that result in stable systems. Since types differ, features of one type may be excluded by other types. Universals – by definition – are features that are never excluded. Any variant that excludes one of these features will qualify as a less fit variant and fall prey to negative selection. How could this be? Features are not selected in isolation, just like genes are not selected in isolation. The subject of selection is the phenotype as the system in action, not the genotype. In the case of grammar, the phenotype is the grammar as it is put to use. The genotype is its neuro-cognitive representation as a computational program which is compiled during language acquisition. A single feature could not be put to use in isolation. It is always embedded in a complex program. Universal features are features of components of these programs without which the program would not work. This are embedded features that cannot be removed or changed in isolation because they are in essential interaction with other features. Any change of such features would be a 'bad' or deleterious mutation; cf. Loewe, and Hill (2010: 1153).

Convergent evolution: It is an open issue whether human languages have a monogenetic or polygenetic history. The time depth for reliable empirical studies on grammars is less than 5k

[57] This is the circle: A particular pattern is recurrent if it is the result of a recurrent change. A change is recurrent, if it recurrently produces a particular pattern.

years. The evolutionary history of homo sapiens dates back at least 300k years (Stringer & Galway-Witham 2017). Since languages do not leave fossils, there is no scientific way of deciding the question of the origin. A unique origin followed by long periods of diversification is not more plausible than a long-period of pre-grammatical pidgin-like communication followed by long periods of grammaticalization with *convergent evolution* of initially different proto-grammar systems. It is highly unlikely that the linguistic capacity of homo sapiens is the result of a unique, huge genetic saltation that spontaneously endowed the new species with the neuro-cognitive fundamentals of a universal grammar. There is no reliable empirical evidence at all for Chomsky's evolutionary conjecture, namely a 'single-mutant' theory of human language (De Boer et al. 2020).

On the other hand, there is ample biological evidence for convergent evolution. For instance, most palaeontologists trace whales, porpoises and dolphins back to Pakicetus, a land-dwelling hoofed mammal. Today, the descendants of this mammal superficially look like prototypical fish, with streamlined bodies, dorsal fins and flippers. This is a result of convergent evolution (Foote et al. 2015). Adaptive changes lead to structures that have similar forms and functions but were not present in the last common ancestor of those groups. Not only sea-dwelling mammals, but Grammars, too, adapt to their respective habitat. In the course of evolution, common superficial characteristics will emerge that have not been inherited from any of the ancestors. But, since evolution is not goal-driven, existing languages may even differ in fundamental[58] grammatical respects.

Untriggered changes: Conjectures that conceive of language changes as products of 'social engineering', driven by "*a pervasive pressure for efficiency*" that "*guides the forms of natural language*" (Gibson et al. 2019: 389) in a permanent process of enhancing the efficiency of the social tools of communication neglect the fact that grammars are stable. Shifting complex phrases to the end of a clause (i.e. "extraposition"), for instance, is a cross-linguistically widely implemented way of enhancing efficiency of parsing and production (cf. Hawkins 1994). Nevertheless, thousands of years of an alleged "pervasive pressure" were not enough for turning strict SOV languages into languages that adopt extraposition.

Evolution does not work like a steadily grinding mill, as Eldredge & Gould (1972) emphasized. Systems with a shorter evolution evolve mostly by *punctuated equilibrium*, and those with a longer evolution evolved mostly by *gradualism*. Punctuated equilibrium means that after a period of very little alteration one or a few major changes occur. Such major changes close many previously available options forever but open new ways for future possibilities to unfold within the limits of the inherited design. Dixon (1997) has proposed such an account for language changes, evaluated critically by Joseph (2001).

In sum, a theory of *grammar* change is a theory of the (neuro-)cognitive, *Darwinian* evolution of grammar systems. In a procedural/declarative model of grammar, the cognitively encapsulated and therefore inaccessible procedural components are the domain of Darwinian evolution. Declaratively stored content, on the other hand, is consciously accessible and therefore open for various kinds of interventions. This is the domain for social factors, although Darwinian

[58] Salish languages lack lexical categories (Jelinek & Demers 1994). Although this wholly impedes phrase-structuring, the grammar has not changed. Needs do not create grammars, and small populations are change resistant.

evolution is not principally excluded from these domains either since retrieval of declaratively stored information is also a procedural capacity and therefore open to effects of natural selection.

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