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Abstract	Biological and cultural evolution are separate factors in determining the structure of language and languages. Cultural evolution allows us to understand properties of morphological systems that are often considered to be outliers without resorting to analytical sleights of hand. The inflectional systems of Dene-Yeniseian and Afro-Asiatic languages are notable for the persistence of their complex and unusual systems of verbal inflection. Both systems can be traced back several millennia over many languages covering a large geographical area. Both exhibit the telltale marks of cultural evolution: they are complex; they are not well designed; they are conservative; and they change incrementally, based on what is there. Almost all Afro-Asiatic languages share an unusual homophony of second and third person singular prefix and two agreement patterns, one containing both prefixes and suffixes and the other exclusively suffixing, serving quite distinct functions across the family. Dene-Yenisean languages (and especially the geographically far-flung members of the Na-Dene branch) are very conservative morphologically and share a templatic pattern of verb prefixes with numerous slots, followed by a verb stem with at most one suffix position. The recently discovered relation between the Yeniseian and Na-Dene families rests largely on this shared verbal morphology. The persistence of these two peculiar systems of verbal morphology can easily be understood as normal cultural evolution and defies other forms of explanation.	
Keywords (separated by “-”)	Cultural evolution - Verbal inflection - Complex morphology - Dene-Yeniseian - Na-Dene - Afro-Asiatic - Semitic - Language change	

Thoughts on Morphology and Cultural Evolution

Mark Aronoff

A struggle for life is constantly going on amongst the words and grammatical forms in each language. The better, the shorter, the easier forms are constantly gaining the upper hand, and they owe their success to their own inherent virtue.
(Charles Darwin (1871))

Nothing about biology makes sense except in the light of evolution.
(Theodosius Dobzhansky (1973))

Nothing about culture makes sense except in the light of evolution.
(Peter Richerson and Robert Boyd (2005))

Abstract Biological and cultural evolution are separate factors in determining the structure of language and languages. Cultural evolution allows us to understand properties of morphological systems that are often considered to be outliers without resorting to analytical sleights of hand. The inflectional systems of Dene-Yeniseian and Afro-Asiatic languages are notable for the persistence of their complex and unusual systems of verbal inflection. Both systems can be traced back several millennia over many languages covering a large geographical area. Both exhibit the telltale marks of cultural evolution: they are complex; they are not well designed; they are conservative; and they change incrementally, based on what is there. Almost all Afro-Asiatic languages share an unusual homophony of second and third person singular prefix and two agreement patterns, one containing both prefixes and suffixes and the other exclusively suffixing, serving quite distinct functions across the family. Dene-Yenisean languages (and especially the geographically far-flung members of the Na-Dene branch) are very conservative morphologically and share a templatic pattern of verb prefixes with numerous slots, followed by a verb stem with at most one suffix position. The recently discovered relation between the Yeniseian and

For Shelly Lieber, who has always had the courage to think outside the box.

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Na-Dene families rests largely on this shared verbal morphology. The persistence of these two peculiar systems of verbal morphology can easily be understood as normal cultural evolution and defies other forms of explanation.

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1 Introduction: Language and Cultural Evolution

This article is a small part of a larger project that aims to show that looking at languages through the lens of cultural evolution can shed light on a number of well-known but previously mysterious linguistic phenomena. I assume with Aristotle that humans are social animals. What sets humans aside from all other animals, no matter how social they may be, is culture. I accordingly adopt Sapir's (1921) general approach to language, which places language firmly in human culture and emphasizes the diversity of both. Languages are cultural artifacts: just as human cultures are manifested in highly structured but highly diverse behavioral patterns and products, so too are human languages. This is not to deny the cognitive unity of human language and languages or the specifically human roots of language or the evolutionary roots of the language capacity (Pinker and Bloom 1990).

Cognition is constrained by the organism, an idea that has roots most prominently in the work of Eric Lenneberg. His entire masterwork, *Biological Foundations of Language* (1967), emanates from a profoundly ethological belief that the cognition of any organism is a product of its biology. Humans, like beavers, stand out largely in the complexity and particulars of their biologically-based cognitive capacity and the variety of its artifacts. As Lenneberg notes in the last paragraph of his book (ibid.: 375), "The biological properties of the human form of cognition set strict limits to the range of possibilities for variations in natural languages." The structure of language and the structures of languages are simultaneously both biologically and culturally driven.

I adopt the evolutionary perspective on culture developed by Robert Boyd and Peter Richerson, one that is inspired by biological evolution but distinct from it. Boyd and Richerson call it *cultural evolution*. Their ideas are worked out in mathematical detail in Boyd and Richerson (1985). Richerson and Boyd (2005) is a less technical but fairly comprehensive presentation. Cultural evolution is different from sociobiology (Wilson 1975 and much other subsequent work) and evolutionary psychology (Barkow et al. 1992). Both of these schools of thought highlight the role of our genetic endowment in determining human behavior and emphasize the fact that modern humans of the Holocene era (approximately the last 15,000 years), the brief period in which pastoralism, agriculture, and large societies have emerged, are genetically the same as our hunter-gatherer cousins. Many of the biological traits that were adaptive in the millions of years since Homo branched off from the other great apes remain prominent in directing our behavior. It is these traits that these schools seek to establish and explore.

The title of Richerson and Boyd's 2005 book, *Not by Genes Alone*, expresses succinctly how the idea of cultural evolution differs from sociobiology and evolutionary psychology. Culture itself, they propose, can be subject to Darwin-style evolutionary thinking, independent of biology but interacting with it. It is this program of applying evolutionary thinking to culture that I join in here. I apply it to language, on the Sapirian assumption that, like all human behavior, language is part of culture as well as part of biology. I will consider only one aspect of language here, a small corner of inflectional morphology, but this article is part of a larger program that looks at a wide variety of morphological phenomena in the light of cultural evolution (Lindsay and Aronoff 2013; Aronoff and Lindsay 2014).

Cultural evolution exhibits many of the well-established properties of biological evolution. Evolution, both biological and cultural, depends on chance. It is blind and undirected, cumulative and conservative: an organism or a cultural system will not change drastically as long as it remains well adapted (as in the famous examples of cockroaches and horseshoe crabs). Theories based on design predict that biological structures did not emerge, but were always intended to be just as they are and are close to perfect. Darwinian theories of evolution predict that complex systems will evolve gradually, will be imperfect, and will have contingent residual properties due to simple inheritance. The same holds for the evolution of complex cultural systems. This inherited historical contingency is one of the most important aspects of Darwinian theory and, as I will show below, crucial to a proper understanding of complex morphological systems. Darwin makes an important observation on contingent inheritance in (1859: 199):

> But by far the most important consideration is that the chief part of the organization of every being is simply due to inheritance; and consequently, though each being assuredly is well fitted for its place in nature, many structures now have no direct relation to the habits of life of each species.

This ability to account for contingent properties of organisms is one of the most beautiful and revolutionary aspects of Darwinian theory and it extends easily to languages, which are replete with structures that have no direct relation to other aspects of the system. In their assumption that *tout se tient*, linguists have long felt an obligation to rationalize contingent properties in purely synchronic terms. Once we take an evolutionary stance, we can accept these phenomena as "simply due to inheritance." This is not to deny their systematicity but simply to give up on the search for perfect design in all aspects of language.

1.1 The Blind Watchmaker

Richard Dawkins makes a forceful argument against design and in favor of biological evolution by natural selection in his 1986 book, *The Blind Watchmaker*. There he elaborates on one of the most surprising results of Darwin's theory of evolution, the way in which it accounts for cases of bad or poor or flawed design. The same argument extends to all types of evolution by selection rather than by

design. The most widely cited case of poor design, and the one that Dawkins discusses in detail, is that of the vertebrate eye. William Paley (1802) had famously brought the human eye forward as an example of the divine watchmaker's design. Responding to Paley, Darwin speculated in *Origins* that an evolutionary account of the eye, though it might seem "absurd in the highest possible degree," was not hard to come up with. His sketch of a solution was fairly accurate. What matters to us, though, is the later discovery that the vertebrate eye is not nearly as well designed as Paley had thought it was, mainly because of the placement of the nerve fibers in front of the retina, resulting in a blind spot where the nerves pass through it. The octopus eye, which evolved independently, has the nerve fibers behind the retina, avoiding the resultant blind spot. The vertebrate eye is a poor design.

Darwin devoted much of his 1871 book, *The Descent of Man and Selection in Relation to Sex* to cases of apparent poor design that can be explained in terms of reproductive success. The most notable is the peacock's tail, which, as Fisher (1930) so elegantly showed, is best understood as the result of a cycle of runaway sexual selection. I know of no direct linguistic analogues to sexual selection but it is not difficult to find examples of rococo linguistic systems on a par with the peacock's tail. Many of them are in the realm of gender, which I will touch on briefly at the end of this article, but I have instead chosen a couple of examples from verbal morphology, because they are easier to lay out.

1.2 The Blind Watchmaker and Linguistic Morphology

I will discuss two cases of blind watchmaking in linguistic morphology, the verbal inflectional systems of the Afro-Asiatic and Dene-Yeniseian language families. Among the world's language families of greatest demonstrated time depth (at least 10,000 years), these two are notable for the persistence of their complex and unusual morphological systems. Semitic languages all exhibit systematic ablaut to an extent unknown elsewhere (Kuryłowicz 1962), while Na-Dene is famous for having many prefixes on verbs, contrary to the overwhelming universal tendency for languages to prefer suffixes over prefixes (Hawkins 1994). Much ink has been spilled in attempts to bring both these systems into the fold of 'normal' morphology. I will argue instead that there is no need to normalize these systems once we take an evolutionary perspective. They are exactly the sorts of things that we should expect from cultural evolution.

I have selected these two language families not only because of their peculiarities but also for autobiographical reasons. The first language whose grammar I studied was Hebrew and the traditional study of Hebrew grammar consists largely of learning the millennium-old analysis of root-and-pattern verb morphology that is enshrined even today in much formal work on Semitic morphology, beginning with McCarthy (1985). I have spent a great deal of time and effort since thinking about the morphology of Semitic languages, mostly Hebrew, but also Aramaic and Maltese (Aronoff 1994; Hoberman and Aronoff 2003). I spent a semester early in

my graduate school career studying Navajo with Ken Hale and Paul Platero, which begat a life-long fascination with Dene verb morphology, a subject so daunting that I have never published on the topic, though I have countless hours reading the monumental descriptions of the languages in the family, most notably Navajo (Young and Morgan 1987, 1992) and Slavey (Rice 1989). This article does not contain an analysis of the morphology of any Dene or Semitic language. If anything, it is a reaction to generative analyses (e.g. Noyer 1997; Rice 2000) whose authors discuss these systems in terms of a distinction between the unusual surface form of the language and a more normal or sensible theoretically underlying system. These are the sorts of analyses that I grew up with but never found comfortable or appealing. This article is based, however, on the assumption we do not permit ourselves to entertain analyses that depart so radically from the surface. The question then becomes how we can understand the peculiarities of Semitic and Na-Dene morphology in some other way. I believe that an evolutionary perspective provides at least a part of such an understanding, though not in terms of a linguistic analysis that goes beyond the by now well-known surface facts. This lack of a traditional analysis will surely frustrate some readers, especially those who are used to understanding language only through the act of analyzing its structure. Such readers might prefer to stop now.

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2 Cultural Evolution

Culture is central to humans and their behavior. As Aristotle observed, humans are social animals. According to Richerson and Boyd (2005), having culture is an adaptation, one large restricted to humans. Pagel (2012) presents a book-length argument for this idea. Signs of culture in other species, though they have been much discussed in the last couple of decades, are few and far between (Laland and Galef 2009). Cultures evolve following Darwinian principles. I adopt Boyd and Richerson's position that cultural evolution does not involve the same units or even types of units as biological evolution and is not dependent on genetic evolution, as opposed to Dawkins's proposed memes, which do follow principles of biological evolution quite closely. The magnitude of human variation, including language variation, is largely explained by cultural evolution. Culture is a population-level phenomenon and it evolves by the accumulation of small variations, just as biological evolution does. As a result, culture may not always appear to be useful or well designed.

Richerson and Boyd identify a number of evolutionary forces specific to culture. These include random forces of mutation and drift; social learning (only humans learn by imitating complex behaviors); biased transmission (prestige bias and frequency-based bias); and selection in the form of competition among cultural variants. We analyze the effect of selection on morphology in Aronoff and Lindsay (2014). To these forces I would add Tecumseh Fitch's wonderfully coined notion of *Mitteilungsbedürfnis*, the overwhelming human need to share (Fitch 2010).

3 Linguistic Morphology and Complexity

Linguistic morphology is the study of the internal structure of words. Linguists have used the term morphology and its equivalents in German, French, and Italian in this sense since the mid-nineteenth century. Variance in complexity among languages is more noticeable in morphology than in any other aspect of language. Some languages (e.g. Vietnamese) have no discernable morphology beyond compounds. Some languages (e.g. Inuit) are famous for the complexity of their words. Languages don't need morphology. Young languages have little or no morphology, either derivational or inflectional. This is true of creole languages (McWhorter 1998) and also of young sign languages, in most respects (Meir et al. 2010). A language can persist for a long time with little or no morphology.

Thai, Vietnamese, and Chinese languages all have existed for millennia with little or no morphology. Gbe languages (e.g. Ewe) and English are examples of simplified morphological systems in families with fairly complex morphology, likely because of phonological change in both instances. Early linguists, beginning with Humboldt, proposed evolutionary theories of linguistic morphology that ranked languages on a pseudo-evolutionary scale of increasing complexity, from isolating languages with no morphology (e.g. Chinese), to agglutinative languages with transparent bead-on-a-string morphology (e.g. Turkish), to inflectional/fusional languages with more opaque morphology (e.g. German, Latin), and culminating in polysynthetic languages where a whole sentence consists of a single polycomponential word (e.g. Inuit, Navajo). But why should morphology become so complex: irregular, non-iconic, non-compositional, and downright difficult to learn? And complex morphology rarely simplifies but instead often persists for many generations, as we shall soon see. Why this too?

A number of evolutionary explanations account for the persistence of complex morphology. The most general is Dollo's Law (1893), according to which evolution cannot reverse itself: "An organism is unable to return, even partially, to a previous stage already realized in the ranks of its ancestors." Dawkins attributes the law to pure probability, but Dollo's Law is closely related to the extreme conservatism of evolution by selection, expressed in the passage quoted above from *Origins*: "the chief part of the organization of every being is simply due to inheritance" (1859: 199). Once a language gets a particular morphological system, it is very hard to lose. That is not to say that the system cannot change or be repurposed, but rather that any change begins from the system that is there. As Jacques Monod has observed (1971: 394):

> The privilege of living beings is the possession of a structure and of a mechanism which ensures two things: (i) reproduction true to type of the structure itself, and (ii) reproduction equally true to type, of any accident that occurs in the structure. Once you have that, you have evolution, because you have conservation of accidents.

In a similar vein François Jacob (1977: 163–164) called nature a *bricoleur* 'tinkerer', because nature never starts with a clean slate but instead tinkers with what it has:

> For the engineer, the realization of his task depends on having the raw materials and the tools that exactly fit his project. The tinkerer, in contrast, always manages with odds and ends. What he ultimately produces is generally related to no special project, and it results from a series of contingent events . . .

These observations hold for any evolutionary system, not just biological evolution but cultural evolution as well, including language. Within language, morphological systems in particular exhibit the telltale marks of evolution: they are complex; they are not well designed; they are conservative; and they change incrementally, based on what is there.

We are now in a position to look in some detail at the two remarkable systems that I mentioned above, Afro-Asiatic and Dene-Yeniseian verb morphology. As noted above, I have selected them not only for their peculiar structure but also because both families are among the oldest known, with little evidence of much change in their morphologies.

3.1 Afro-Asiatic

The Afro-Asiatic language family occupies a broad swath from the Fertile Crescent, down through the Arabian peninsula, across the Levant and into the northern third of Africa, sweeping down into the Horn. Its subfamilies include Semitic, Berber, Chadic, Cushitic, and Omotic (as well as the now extinct Egyptian branch). Conservative estimates (Ehret 1995; Bellwood 2004) posit the origin of Afro-Asiatic as at least 12,000 years ago, in either the Horn of Africa or the Southwest Sahara. All the subfamilies, except for Chadic which has lost verbal agreement morphology, share a prefixing verb conjugation for subject agreement, with the prefixes *ʔ-* for 1st person singular, *t-* for both second person singular and third person feminine singular, and *y-* for third person masculine singular. The system remains intact in most Arabic dialects and in colloquial Israeli Hebrew. The peculiar homophony of the t- forms is typologically puzzling: although there are no statistically reliable data on the question, I know of no other cases of homophony between second and third person singular subject agreement. Hetzron (2009: 548) goes out of his way to "note the homonymy of second person singular masculine ~~masculine~~ and third person singular feminine." The fact that this homophony has remained firmly entrenched without varying over at least 12,000 years attests to the conservative nature of morphology: if it ain't broken, don't fix it. It is also perfectly consonant with an evolutionary account, in which vestigial features are normal, and puzzling on any other.

In addition to the prefix marker for subject person agreement, the prefixing conjugation of Afro-Asiatic has suffixes marking feminine gender or plural number in some forms. Again, this is ancient, pervasive, persistent in many of the modern languages, and typologically odd. Here we have real data. WALS contains a chapter on prefixing versus suffixing in inflectional morphology. The calculation of the index is complex (Dryer 2013) but subject affixes are among its most heavily

weighted components. Only 15% of close to a thousand languages in the sample are classified as "equal prefixing and suffixing." The sample includes among this set both an Arabic and a Berber dialect as well as Mehri (a South Arabian language spoken in Yemen and Oman), all geographical outliers around the Mediterranean world.

Besides the prefix conjugation, Afro-Asiatic had a suffix conjugation (Satzinger 1999; Hetzron 2009), where the person and gender markers are fused. Much speculation surrounds the original functions of these two conjugations, with no firm conclusions. Regardless of their ancestral values, both conjugation types remain in many daughter languages, especially in Semitic, where they have long been called *perfect* and *imperfect*. In Arabic, the prefixing imperfect is used for the present tense and the suffixing perfect for past tense. Their use in Biblical Hebrew has been intensely debated for a millennium and has been discussed in greatest detail by Waltke and O'Conner (1990). The traditional view is that the imperfect is a future tense and the perfect a past tense but that their tense values can be switched by the "reversative vav [conjunction]." In all varieties of Hebrew since the Babylonian exile, the prefix conjugation has been used for the future tense and the suffixed conjugation for the past. Regardless of their diverse functions in the daughter languages, the two conjugation types have persisted in glorious asymmetry, further striking testimony to the power of sheer continuity in morphological evolution. Numerous attempts have been made to rationalize or explain the differences between the two conjugations (e.g. Lumsden and Halefom 2003), but such rationalizations remain just that from an evolutionary perspective.

3.2 *Dene-Yeniseian*

Among the most dramatic linguistic discoveries of this century is ~~the~~ Edward Vajda's demonstration of unity of the Dene language family of North America with the Yeniseian family of Central Siberia, represented by the sole surviving language, Ket (Vajda 2010a, b, 2011), with a proposed time depth of 15,000 years. Much of Vajda's evidence is morphological, lying largely in similarities between the very peculiar and long known morphological verb template of the Na-Dene languages with that of Ket, though Vajda also adduces genetic similarities between the populations.

The term Na-Dene was coined by Edward Sapir (1915) to name a family that includes the Athabaskan languages, along with the two languages Eyak and Tlingit. The Dene (Athabaskan) languages cover a wide swath across Alaska and the northern territories of Canada, down into the northern regions of Western Canada, and in a narrow strip along the coast of British Columbia and the American northwest. A geographically distant but linguistically very close southern branch of Dene languages consists of Navajo and a number of Apache languages. These communities must have migrated from the Canadian north (Morice 1907; Sapir 1936). Despite the great geographical distance and the presumed split from the rest

of the Dene family about a millennium ago, the Southern Dene languages remain remarkably similar to their northern cousins. Morice (1907: 720) emphasized:

> a particularity which, considering the vast extent of the area occupied by the Dené family and the great isolation of several of its branches, I consider nothing short of wonderful: I mean the practical identity, the morphological and grammatical unity of all its dialects.

From a purely morphological point of view, the Dene languages are among the most unusual in the world. They have a devilishly complex system of verbal inflection that consists of a large number of prefix slots with complicated interactions among the slots, followed by a verb stem, which once contained a modal or aspectual suffix, but whose members have become fused in many cases (Pike and Becker 1964; Pinnow 1974; Hardy 1979; Rice 1995; Young and Morgan 1992). Although some analysts attempt to untangle the root and suffix of this stem, others (notably Young and Morgan) prefer to simply list a "stem set" for each verb stem. The stem is preceded by a thematic prefix to form what Sapir called a theme. Nine or ten distinct prefix slots precede the verb theme. The details of the system have been worked out exhaustively for Navajo by Young and Morgan (1987) and for Slave by Rice (1989).

Enter Ket. Vajda's most powerful evidence for a genetic relation between Yeniseian languages and Na-Dene is what Diamond (2011: 292) calls "Ket's … bewilderingly complex strings of eight verb prefixes [that] were utterly out of place in Siberia – otherwise occupied by toneless suffixing languages related to Turkish and Finnish – and by how those tones and prefixes corresponded in detail to Na-Dene languages." Diamond notes (ibid.): "The parallels he identifies include a dozen grammatical prefixes and about 100 cognate words with sound correspondences. [Furthermore] the prefixes appear in the same sequence between Yeniseian and Na-Dene verbs." Diamond then asks (ibid.):

> Why do Yeniseian and Na-Dene languages still show such a strong relationship if they diverged 12,000 years ago, when other languages diverge beyond recognition after 5,000–10,000 years ago? Either Yeniseian and Na-Dene languages really diverged only 5,000 years ago, or they are unusually conservative and evolve especially slowly.

In his much more skeptical review, Campbell (2011: 448) raises similar concerns about the evidence from morphology:

> The verbal affix templates appear similar in the two families, making the comparison both impressive to some and suspicious to others. Since complex verb morphologies are constantly changing, it would be astounding if both Yeniseian and Na-Dene had managed to retain so much of the original morphology from which the two families are assumed to have developed in such strikingly similar form over such a long time span. In older language families, the morphology has changed much, resulting in different typological profiles for related languages, as seen in branches of Algic, Indo-European, Niger-Congo, Uralic, and Uto-Aztecan.

But as we have just seen for Afroasiatic, languages *do* retain complex and largely unmotivated morphological systems for 10,000 years. Just as in biological species, there is no constant rate of evolution that applies to all languages and just as some species have remained relatively unchanged for millions of years, so too should we expect some languages to remain unchanged, at least in certain of their

properties. It has been puzzling to linguists that many of the members of these two language families have remained unchanged in just those aspects of their morphological structure that appear to be most baroque. I have tried to show here that an evolutionary perspective can help to assuage their puzzlement.

4 Conclusion

Cultural evolution can shed light on well-known but puzzling aspects of the verbal morphology of two prominent language families, Afro-Asiatic and Na-Dene. My account is not ambitious: I have not attempted to explain these peculiar systems and I have no desire to do so. In fact, what puzzles me most at this point is the zeal of others to justify their existence. Like all successful systems, the survival alone of these peculiar morphological systems should be adequate testimony to their value.

There are many areas beyond verbal morphology that should be fruitful for the evolutionary approach that I have outlined. Gender systems come to mind. They have arisen in a number of places around the world and can be quite baroque and very persistent. Remarkably, many members of three of the language families that Campbell cites as examples of changes in morphological typology, Algic, Indo-European and Niger-Congo, have retained their gender systems largely intact, despite the fact that they have such different cognitive bases: Algic gender is based on animacy, Indo-European on sex, and Niger-Congo on a variety of factors. Neither Uto-Aztecan not Uralic are normally believed to have had gender systems. Gender has thus persisted in all of the families that Campbell cites in which it could have done so, contrary to the claim that he is making.

Once we give up trying to explain persistent complex morphological phenomena synchronically we may be in a much better position to understand them. An evolutionary perspective places no special value on either simple systems or complex systems. All linguistic morphological systems and all languages are equal from an evolutionary perspective. All linguistic morphological systems and all languages are contingent and accidental from an evolutionary perspective. An evolutionary perspective predicts that a complex morphological system will not change significantly unless there is a strong reason for it to do so. In the words of William Empson, "The waste remains, the waste remains, and kills."

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