

Article

Explaining Change in Language: A Cybersemiotic Perspective

Marcel Danesi

Collaborative Master's Program in Semiotics, Victoria College, University of Toronto, 101 Wymilwood Hall, 73 Queen's Park Crescent, Toronto, Ontario M5S 1K7, Canada;
E-Mail: marcel.danesi@utoronto.ca

Received: 14 October 2009 / Accepted: 2 December 2009 / Published: 11 December 2009

Abstract: One of the greatest conundrums in semiotics and linguistics is explaining why change occurs in communication systems. The descriptive apparatus of how change occurs has been developed in great detail since at least the nineteenth century, but a viable explanatory framework of why it occurs in the first place still seems to be clouded in vagueness. So far, only the so-called Principle of Least Effort has come forward to provide a suggestive psychobiological framework for understanding change in communication codes such as language. Extensive work in using this model has shown many fascinating things about language structure and how it evolves. However, the many findings need an integrative framework for shedding light on any generalities implicit in them. This paper argues that a new approach to the study of codes, called cybersemiotics, can be used to great advantage for assessing theoretical frameworks and notions such as the Principle of Least Effort. Amalgamating cybernetic and biosemiotic notions, this new science provides analysts with valuable insights on the *raison d'être* of phenomena such as linguistic change.

Keywords: language change; Principle of Least Effort; Zipf's Law; cybersemiotics; symbolization; communication effort; cybernetics; linguistic theory

1. Introduction

The primary task of any science is to explain how and why phenomena are the way they are by means of suitable models or theories and, as new facts emerge or are collected about the relevant phenomena, to subsequently adjust, modify, or even discard the models and theories on the basis of the new data. In this piecemeal and cumulative fashion, the ultimate goal of science is to explain what

Aristotle called the “final causes” of the components of reality. This is the epistemological platform on which the physical sciences are implanted. The same platform was adopted by the modern human sciences in the nineteenth century. Figuring out the final causes behind language and its origins was, in fact, the original impetus behind the emergence of linguistic science in that century, when the systematic study of language families started in earnest. Specific to the research agenda in that era was determining the causes of linguistic change and developing an appropriate theory of linguistic evolution. Various early notions crystallized to explain change, leading in the early part of the subsequent twentieth century to two interesting theoretical paradigms, known as the Principles of Economy and Least Effort, both of which continue to be debated to this day. Both were based on the notion that humans intervene in communication systems to make them more efficient, economical, and effortless. In so doing, they initiate change in these systems.

Both principles were generally relegated to marginal status in the previous century within general linguistics vis-à-vis the universalist paradigm—a paradigm which maintains that the language faculty is an innate structure of the human brain and, thus, that its underlying (or deep-structure) principles of construction are impervious to intervention from environmental influences such as human intentionality. Known as Universal Grammar Theory, it traces its roots to ancient philosophies and, more specifically, to the seventeenth century, when a group of French scholars, known as the Port-Royal Circle, argued essentially that a set of principles of sentence-formation existed in the human brain at birth. Differences in actual grammars were then explained as the result of how this set of rules was applied *in situ*. The linguist Noam Chomsky [1-5] brought the Port Royal paradigm into contemporary linguistics starting in the late 1950s, refining it considerably over the years and, in the process, greatly influencing the development of linguistic theory. As a result, principles such as those mentioned above fell by the wayside. However, since the 1980s, with the epistemological foundations of Universal Grammar Theory being challenged by work on metaphor and iconicity in language [6-9], the tide has changed, allowing the principles to reemerge and to be reevaluated in the light of current scientific paradigms.

Today, there has been a veritable resurgence of interest in ideas relating language form to meaning with a proliferation of in-depth technical studies on how changes in form regularly interact with changes in other aspects of grammar and vocabulary. The goal here is not to present new statistical data on the operation of this interaction. It is simply to consider principles such as that of Economy and of Least Effort in the light of the emerging science of *cybersemiotics*, a branch of both cybernetics and semiotics, put forward by the Danish semiotician Søren Brier [10-16]. This science blends notions from the cybernetic approach to the study of regulation and control in animals, viewed as self-governing entities consisting of parts and their organization, and from the semiotic approach to meaning as a semiosis (sign-based) phenomenon. As is well known, cybernetics was conceived by the late mathematician Norbert Wiener, who coined the term in 1948 in his book *Cybernetics, or Control and Communication in the Animal and Machine* [17]. Wiener may not have been aware that the same term was employed in 1834 by the physicist André-Marie Ampère to designate the study of government in his classification system of human knowledge. Ampère, for his part, probably took the term from Plato's *The Laws*, where it designated the governance or “steering” of people. In the area of language, the cybersemiotic agenda would involve, in my view, studying the relation of mechanisms in language that allow speakers to control the efficient use of grammar and vocabulary, without any

damage to, or loss of, meaning. Brier's work will, in my estimation, become instrumental in bringing the overall scientific blueprint of biosemiotics and cybernetics into the domain of linguistics.

2. Cybersemiotics

Traditional cybernetics—which Brier calls “first-order” cybernetics—views communication in all self-contained complex systems (biological and mechanical) as analogous. It is not interested in the material forms of such systems, but in the ways in which these are organized. Because of the increasing sophistication of computers and the efforts to make them behave in humanlike ways, this school of cybernetics today is closely allied with artificial intelligence and robotics, drawing heavily on ideas developed in both these sciences and in information theory as well [18-20]. Cybersemiotics—which comes under the rubric of what Brier calls “second-order” cybernetics—expands this basic paradigm to encompass the study of how human systems originate and develop, and how they are both different and similar across species. As such, cybersemiotics is closely allied to *biosemiotics*—the study of semiosis across organisms and species [21-25]. A fundamental objective of this science is to distill common elements of semiosis from its manifestations across species, integrating them into a taxonomy of notions, principles, and procedures for understanding the phenomena of semiosis and communication in their globality. In many ways, the two approaches share the same intellectual and methodological territory. The concept of modeling systems, for instance, is central to both cyber- and biosemiotics. A model is a sign, text, or some complex form that a certain species uses in order to represent the world according to its own needs and propensities. In the human species, words, for example, are verbal models of things, events, *etc.* in the world, and musical tones are models of audible phenomena that are normally tied to emotional processes. A modeling system is species-specific allowing a species to generate and comprehend models for its specific biological, emotional, and other reasons. Cybersemiotics is concerned especially with how humans use models to encode information, transforming such information into meaning-bearing forms (verbal and nonverbal). In a sense, models lower the entropy (randomness) present in a system (such as language) to give it predictability and pattern. Any change in this system is an entropic one.

Brier himself wrote an in-depth analysis of communicative change in a 2003 paper [15], expanding upon it later in his 2008 book, *Cybersemiotics* [16]. Based in part on the key ideas put forward by Deacon in 1997 [26] that symbols change through a form of creative adaptation, called *autopoiesis*, Brier's approach is intended to show how the encoding of information interacts with human intentionality (and other aspects of human mentality). As understood in terms of his “second-order cybernetics,” *autopoiesis* refers to the process of a modelling system, such as language, of regulating its own operation. In simple words, humans control language. In contrast, machines, which belong to “first-order” cybernetics, are *allopoietic*, are controlled by someone or something else. As is well known, the term was introduced by Maturana and Varela in their famous 1973 book *Autopoiesis and Cognition* where they suggest that a cell participates in producing or at least shaping its various biochemical agents and structures, so as to ensure its efficient and economical operation. Cybersemiotics comes into this picture by suggesting that meaning in human sign systems plays a role in both shaping *autopoiesis* and in dealing with entropy.

My goal here is to look more specifically at how this basic cybersemiotic view of organisms and systems can be used to assess principles such as those of Economy and Least Effort. Most of the claims I will make here are not new, of course. But I believe that reframing them in cybersemiotic terms might provide insight from a new and unexpected angle. In effect, I intend to articulate several “cybersemiotic laws” of language change which take into account economization, efficiency and autopoiesis. These will be called the *Meaning-Preserving Principle*, the *Meaning-Expanding Principle*, and the *Symbolization Principle*. All three fall under the rubric of second-order cybernetics, since they are intended to illustrate how languages are “self-adjusting” systems, highly sensitive to pragmatic and historical variables.

3. Economy in Language

Starting in the late eighteenth and early nineteenth centuries, philologists started viewing the study of change in language as a crucial one in the quest to understand the overall phenomenon of why language exists in the human species and how it interacts with cognition. The German scholar Wilhelm von Humboldt, for instance, saw the particular structure of a given language, which he called the *innere Sprachform* (internal structure), as conditioning how people came to view reality [27]. Languages were seen, therefore, as adaptive codes, allowing people to develop verbal signs for encoding and evaluating the particular environments in which they existed. As Humboldt [27] aptly put it, language has an “internal structure, which determines its outer form and which is a reflection of its speakers’ minds; the language and the thought of a people are thus inseparable.” In the eighteenth century, detailed surveys of the vocabularies of languages became increasingly more precise culminating in the general view that various groups of languages formed “families,” having evolved from a common source language.

As philologists started comparing languages systematically, they started noticing that the sounds in related words often corresponded in regular ways. For example, they discovered through extensive comparisons that the initial /p/ sound of Latin words such as *pater* (“father”) and *pedem* (“foot”) corresponded structurally to the initial /f/ sound in the English cognates *father* and *foot*. They thus deduced that there must have been a phylogenetic link between Latin and English and, thus, that the two languages belonged to the same family tree. The method used to make such linkages came to be called *comparative grammar*—a term coined in 1808 by the German scholar Friedrich Schlegel [28]. Systematic sound changes were called *sound shifts*. In the example above, the sound shift was ascribed to English, because Latin, being an older language, was closer in time to the common source language. From the relevant research on sound shifts, a movement emerged, based mainly in Germany, called the *neogrammarian* movement, which introduced the key notion of *sound law* to explain shifts such as initial /p/ to /f/ in English. Essentially, the neogrammarians saw sound shifts as the result of the reduction of articulatory effort. For example, the cluster /kt/ in Latin, in words such as *factum* (“fact”), *lactem* (“milk”), *noctem* (“night”), and *octo* (“eight”), developed into sounds in the Romance languages that eliminated or attenuated the articulatory distance between the /k/ and /t/ in the original cluster. For example, in Italian, the /k/ was assimilated to the /t/ to produce a double consonant, which requires less effort to pronounce than the original cluster—*fatto*, *latte*, *notte*, *otto*. However, not all the facts of change confirmed the sound laws put forward by the neogrammarians. To explain exceptions,

they introduced the notion of *borrowing*. According to one sound law, initial Latin /d/ should correspond to English /t/, as it does in *dentalis* vs. *tooth*. The English word *dental*, however, has a /d/ sound instead. The conclusion is that English borrowed it directly from Latin without modifying the pronunciation of the initial /d/; whereas *tooth* (which has the expected /t/) was a native English version of the original word. The concept of borrowing is an early crystallization of an implicit cybersemiotic notion, namely that human sign systems do not evolve simply through the channel of pure entropic or self-regulating forces, but adaptively or, more precisely, autopoietically. Of course, the philologists did not identify borrowing as such, but there is little question in hindsight that it was part of a cybersemiotic solution to human cleverness and practicality—an innate ability that the semiotician Charles Peirce [29] called “logica utens” throughout his writings. This is defined as a kind of practical logic that guides us in our everyday interactions with reality.

The work on sound laws made it obvious that a true theoretical science of language was coming into existence. Towards the end of the nineteenth century, language scientists were beginning to study language forms independently of their phylogenetic roots. It was the Swiss philologist Ferdinand de Saussure [30] who put the finishing touches on this new blueprint for language science by making a distinction between the historical study of sounds, which he called *diachronic*, and the systematic study of a language at a specific point in time, which he called *synchronic*.

The concept of sound law was, *ipso facto*, the first explanatory theory of change in language [31]. Sound changes in general seemed to reflect attempts to mitigate articulatory difficulties and, thus, overall, to make speech much more effortless. Of course, the early linguists found many counterinstances to this general tendency, whereby speakers of languages actually introduced complexities into their speech habits for various social and cultural reasons. But, if left alone, the tendency in speech seemed to be towards simplicity, not complexity. This would explain why language grammars tend towards reduction or compression over time. It would also explain the *raison d'être* of borrowing, because it takes much less cognitive effort to borrow something from another language to fill a conceptual gap in one's own language than to create a new form from scratch. For example, the English suffix /-er/, which is added to verbs to form corresponding nouns (e.g. *baker* from *bake*), was borrowed from the Latin suffix /-arius/. The use of this suffix reduces the cognitive effort that would otherwise be needed to come up with, and then remember, different lexical items for separate verb and noun forms.

Work on explaining change in language was abruptly marginalized with the broad acceptance of Saussure's emphasis on the need to study languages synchronically. It was only in the 1950s that the French linguist André Martinet [32] revived the notion that languages changed as a result of the need to reduce effort in communication. According to Martinet, change in language systems, which Saussure had called *langue*, occurred as the result of an unconscious economizing force present in *parole*, or the use of *langue* in actual speech situations. Calling it the Principle of Economic Change, or simply the Principle of Economy (PE), Martinet posited that complex language forms and structures tended towards reduction or economization over time because of usage (*parole*). For example, the opposition between short and long vowels in Latin, which produced a relatively large inventory of distinct words in that language, disappeared in the emerging sound systems of the Romance languages. Latin had ten distinct vowel sounds, equivalent approximately to the vowel sounds represented by the English letters *a*, *e*, *i*, *o*, *u*. In addition, each vowel was pronounced as either long or short—for

example, the pronunciation of the word spelled *os* could mean either “mouth” or “bone,” depending on whether the vowel was articulated long or short (respectively). The ten-vowel phoneme system was, to a large extent, reduced in the Romance languages, in line with the PE. Distinctions of meaning were preserved nonetheless, but with less phonic material. Using the insights of cybersemiotics, a general principle can be developed to explain an outcome such as this one. It can be called the Meaning-Preserving Principle, or MPP, which claims that a reduction in a system due to economizing tendencies often involves a preservation of meaning.

4. Meaning-Preserving and Meaning-Expansion Principles

The MPP can be used to explain why syntactic languages—languages in which word order and organization determines meaning—have evolved from previous stages in which morphology (the structure and make-up of the words themselves) was the determinant in meaning ascription. A classic example of the operation of this principle is the loss of the Latin declension system in the Romance languages. In a sentence such as *Puer amat puellam* (“The boy loves the girl”) the case structure of the words is what allowed Latin speakers to extract the appropriate meaning from it. Indeed, the words of the sentence could have been permuted in any way and the meaning would have remained the same, because the ending on each word informed the speaker or listener what relation it had to the others: *puer* (“boy”) is in the nominative case and thus will be interpreted by a speaker as the subject of the sentence, and *puellam* (“girl”) is in the accusative form (nominative = *puella*) and thus will be interpreted as the object of the sentence, no matter where it occurs in it. In English, on the contrary, *The boy loves the girl* and *The girl loves the boy* mean different things. English is a syntactic language (also known as an isolating language), Latin is not. It is called a fusional language. But older stages of English had case structure and thus meaning was more dependent on morphology than it was on syntax. In both modern-day English and the Romance languages, syntax plays a much greater role than does morphology. But this was not the case in older forms of English or in Latin, where sentence-structure played a diminished role in meaning ascription. As Edward Sapir [33] aptly put it in his classic treatise on language: “The sentence is the outgrowth of historical and of unreasoning psychological forces rather than of a logical synthesis of elements that have been clearly grasped in their individuality.” The shift of the meaning burden to syntax in English and the Romance languages was brought about by phonetic changes in line with the PE. For example, the elimination of the final /-m/ in accusative forms and the dropping of final consonants generally from Latin, meant that case suffixes no longer signaled grammatical distinctions. This happened as early as the fourth century. Over time, this economization of form led to the reconstitution and even elimination of the entire case system. Different devices were used and even developed by the Romance languages to maintain case distinctions—prepositions, for example, became necessary to distinguish case functions. This transfer of meaning from morphological structure to syntactic order suggests that syntax is a later development in languages.

Meaning preservation occurs in second-order (human) semiotic systems, as Brier’s theoretical model implies. It is an adjustment to change at the signifier level (the physical form of signs), compensating with adjustments at the signified level (the level of reference or conceptualization).

Clearly the MPP would not apply to first-order cybernetic systems, which do not rely on meaning (semiosis) in order to operate effectively.

Not all meaning is preserved, however, in language change. Thus, another principle is needed to explain why, in some cases, the result of economizing leads to meaning expansion and, thus, to the discovery of new meanings. This can be called the Meaning-Expansion Principle (MEP). This principle suggests, paradoxically, that a reduction in form leads (at times) to an expansion in meaning, opening up new representational and communicative possibilities. For example, alphabet characters have much more meaning than just representing phonic structures in a graphic medium. They can be used to classify things (alphabetic order) and as single signs to represent something in and of itself: “A” can be used to indicate “top quality,” “X” something forbidden, and so on. Often, meaning expansion leads to discovery. For instance, the decimal system is a maximally efficient one. Not only, but it has made it possible for decimal signifiers (forms) to suggest new ideas, or signifieds, on their own. For example, the use of superscripts in the representation of exponential numbers, which was introduced in the Renaissance period, led serendipitously to the investigation of new laws governing numbers. This would have been impossible without the superscript notation. Exponents are shorthand forms for multiplication, making it more efficient for people to multiply repeating digits. Thus, 5^9 is much easier to read and understand arithmetically than is $5 \times 5 \times 5$. At first, this notation was used simply as a way to abbreviate the multiplication of identical digits. But, by working with the notation in new and creative experimental ways mathematicians came up with novel knowledge, such as, for example, that n^0 is always equal to “1.” Without going into the simple proof of this here (any basic mathematics textbook will contain it), suffice it to say that it has revealed a property of “0” that would not have been discovered otherwise. Nor would the branch of mathematics known as logarithm theory ever have emerged without the new exponential notation. The history of mathematics is characterized by economizing notational creations that have led serendipitously to mathematical discoveries.

5. The Principle of Least Effort

The Principle of Economy is not, in itself, an explanatory theory of *why* change occurs in the first place. Nor are its derivative corollaries, which I have called the MPP and the MEP. To unravel the causes of change, ultimately one must resort to a psychobiological assessment of the autopoietic forces at work in change, as did the neogrammarians and as suggested by second-order cybernetic analysis. The explanatory framework under which such inquiry has been conducted in the past is that of the so-called Principle of Least Effort (PLE)—a principle that has, surprisingly, received relatively little attention on the part of cyberneticians and semioticians, but which is now being investigated vigorously in various other domains of science. Indeed, even a minimal bibliographic assessment of the work being conducted on the validity of the PLE here would constitute an enormous task. All this suggests its general acceptance, despite the fact that it has often been critiqued and even assailed in the past. The operation of the PLE in language was identified in the 1930s by the Harvard linguist George Kingsley Zipf [34-37], who claimed that its operation was independent of language and culture. As Van de Walle and Willems [38] write, Zipf saw language as a “self-regulating structure” evolving “independently from other social and cultural factors.” The PLE was, thus, unwittingly cogitated as a

fundamental cybernetic one—I use the word “unwittingly” because there is no evidence that Zipf understood it in this way. The PLE is the reason why speakers minimize articulatory effort by shortening the length of words and utterances. This normally leads to change in grammar and vocabulary. The changes, however, do not disrupt the overall system of language, since they continue to allow people to interpret the meaning of words and utterances unambiguously and with least effort (MPP) or, in some cases, to find new meanings for them (MEP).

By studying large samples of written text, Zipf noticed that there seemed to exist an intrinsic statistical interdependence between the length of a specific word (in number of phonemes) and its rank order in the language (its position in order of its frequency of occurrence in texts of all kinds). The higher the rank order of a word or expression (the more frequent its usage in *parole*), the more it tended to be “shorter” (made up with fewer phonemes). For example, he found that articles (*the*), conjunctions (*and*, *or*), and other function words (*to*, *it*), which have a high rank order in English (and in any other language for that matter), are typically monosyllabic, consisting of 1–3 phonemes. What he found as being even more intriguing was that this compression force in language does not stop at the level of function words. It can be seen to manifest itself in a host of common tendencies, such as the abbreviation and acronymy of commonly used phrases, (*FYO*, *ad*, *photo*, *24/7*, *aka*, *DNA*, *IQ*, *VIP*, *etc.*). It also crops up in the creation of technical and scientific notation systems, such as indexes, footnotes, bibliographic traditions, and so on and so forth. This led Zipf to articulate a law of language economy which proclaims that the more frequent or necessary a form is for communicative purposes, the more likely it is to be rendered “compressed” or “economical” in physical structure. The reason for this seems to be an innate psychobiological tendency in the human species to expend the least effort possible in speech.

To grasp the essence of Zipf’s Law, as it came to be called, all one has to do is take all the words in a substantial corpus of text, such as an issue of a daily newspaper or a novel, count the number of times a word in it appears and then tabulate its frequency against its length. Plotting the frequencies of the words on a histogram, sorted by length and rank, the resulting curve will be found to approach the shape of straight line with a slope of -1 . If rank is given by r and frequency by f , the result C of multiplying the two ($rf = C$) is constant across texts: that is, the same word presents the same C in texts of relative size. For the sake of historical accuracy, it should be mentioned that the first to look at word length and frequency in this way was, to the best of my knowledge, the French stenographer J. B. Estoup in his 1916 book, *Gammes Sténographiques*, which relays work he had been conducting on word lengths in French in previous years. Estoup may, in fact, have been the first to show that rank and frequency were related by the hyperbolic law just discussed.

A study of Zipfian histograms has revealed some truly remarkable tendencies. For example, it has shown that the magnitude of words tends, on the whole, to stand in an inverse relationship to the number of occurrences. Thus, the more frequent the word is in actual communicative behavior the shorter it tends to be—words such as *advertising* and *photography*, which are used frequently, have become shortened to *ad* and *photo*. The research has also shown that the number of different words in a text seems to be ever larger as the frequency of occurrences becomes ever smaller. This result surfaces no matter what type of text is involved. Indeed, given a large enough corpus of any textual form (newspaper, recipe, novel, scientific treatise, *etc.*), the exact same type of curve results from counting words—the larger the corpus the more the curve tends towards the slope -1 . The particular

language also does not change this result. Zipf himself used data from widely-divergent languages and found this to be true of any of the languages he investigated. Not only words, but also syllables, morphemes, Chinese characters, and the babbling of babies have been found to fit the same curve pattern. Given this unvarying outcome, the relation of word frequency (p_n) to rank order (n) was formalized by Zipf as follows: $\log p_n = A - B \log n$ (where A and B are constants and $B \approx 1$).

Since the mid-1950s, research on the PLE in various disciplines has established empirically that there is a tendency in all aspects of language towards the compression of high-frequency forms [19,39-46]. Remarkably, the PLE has been found to surface in many types of activities and behaviors, from numeration patterns [47] to the distribution of city populations [48-49]. The mathematician Benoit Mandelbrot, who developed the modern-day branch of mathematics known as fractal geometry [50-51], became fascinated by the PLE, seeing it as being a particular manifestation of a scaling law in biology. As a consummate mathematician, Mandelbrot also made appropriate modifications to Zipf's original Law and, generally speaking, it is Mandelbrot's version that is used today to study frequency distribution phenomena in linguistics generally. Moreover, it should be mentioned that the PLE was known long before Zipf, even though it was not identified as such. It was implicit, for example, in the sound laws formulated by the neogrammarians. Nineteenth-century mathematicians, too, found that if the digits used for a task were not entirely random but socially or naturally based, the distribution of the first digit was not uniform—1 tended to be the first digit in about 30% of cases, 2 would crop up in about 18% of cases, 3 in 12%, 4 in 9%, 5 in 8%, *etc.* This pattern was discovered by the American astronomer Simon Newcomb in 1881, who noticed that the first pages of books of logarithms were soiled much more than the remaining pages. In 1938, mathematician Frank Benford investigated lists of data, finding a similar pattern in income tax and population figures, as well as in the distribution of street addresses of people listed in phonebooks. Zipf's main contribution was in showing empirically that patterns of this type manifest themselves regularly and blindly in human representational efforts, and especially in language.

Overall, three basic phenomena are now accepted virtually as fact, following Zipfian analyses of texts. These are as follows: (1) monosyllables are the most frequent words in languages across the world; (2) polysyllabic words that gain frequency are rendered monosyllabic through abbreviation, acronymy or other form-compressing processes; and (3) in general the most frequent words account for most of the actual constitution of sizeable texts, with the first ranking 15 words accounting for 25%, the first 100 for 60%, the first 1,000 for 85% and the first 4,000 for 97.5%.

One area in which the PLE can be seen to have operated concretely is in the evolution of alphabets [52]. Before alphabets, people passed on knowledge primarily through the spoken word and pictography. The latter is so basic and instinctive that, even in alphabet-using cultures, it has hardly disappeared. It can, in fact, be seen all over the modern cultural landscape, from figures on washroom doors, to logos and trademarks in advertising. Alphabets emerged as extensions of pictographs as strategies for recording and transmitting knowledge more efficiently, allowing for the use of a handful of letter symbols *ad infinitum* to represent all the existent (and potential) words of a language. In line with the MEP, the letter-for-sound basis of alphabetic writing has drastically altered the ways in which we record knowledge, and how we have come to perceive it and even bring it to light. The importance of alphabets to the constitution of modern civilizations has been discussed abundantly and repeatedly in many fields, as has its emergence to replace pictography as an efficient method for recording

knowledge [53-65]. But, to the best of my knowledge, rarely has anyone contemplated ascertaining why such a replacement came about in the first place. The general storyline offered in the relevant literature is that alphabet characters, as stylized derivatives of pictographs, came to replace the latter in the marketplaces of the ancient world when people started realizing that they could be used economically to represent the sounds in words. That watershed event in human history is portrayed as a fortuitous social episode, not as a product of some larger psychobiological force at work in the human species. Simply asserting that alphabets came about to render the encoding and use of information efficient does not in any way explain why efficiency is a motivating force in representation and communication.

Of course, all these findings relate to the form of words or, as mentioned, to the level of the signifier. At first, Zipf did not bring meaning into the statistical picture. However, when he did, he also found some fascinating patterns. For example, he discovered that, by and large, the number of words (n) in a verbal lexicon or text was inversely proportional to the square of their meanings (m): $(n)(m)^2 = C$. In 1958, psycholinguist Roger Brown subsequently claimed that Zipfian analysis applied to meaning in a general way, namely to the Whorfian concept of codability. This notion implies several subconcepts [66]. The best known one is that language users encode the concepts that they need. And this determines the size of their vocabularies and the constitution of their grammars. If speakers of a language are involved in using colors a lot, then they will develop more words for color concepts than do other languages; if they have to deal with snow in their environment on a regular basis, then they will develop more words for types of snow than will other cultures. Codability also extends to the grammar (verb tenses, noun pluralization, *etc.*), which is seen as a culture-specific guide for understanding reality and to lexical shape and length. Brown [67] put it as follows:

Zipf's Law bears on Whorf's thesis. Suppose we generalize the finding beyond Zipf's formulation and propose that the length of a verbal expression (*codability*) provides an index of its frequency in speech, and that this, in turn, is an index of the frequency with which the relevant judgments of difference and equivalence are made. If this is true, it would follow that the Eskimo distinguishes his three kinds of snow more often than Americans do. Such conclusions are, of course, supported by extralinguistic cultural analysis, which reveals the importance of snow in the Eskimo life, of palm trees and parrots to Brazilian Indians, cattle to the Wintu, and automobiles to the American.

This interpretation of Zipfian theory has been critiqued in the relevant literature [68-70]. Miller (1981) also questions the overall findings of Zipfian analysis. He dismisses such work abruptly as follows [69]: "Zipf's Law was once thought to reflect some deep psychobiological principle peculiar to the human mind. It has since been proved, however, that completely random processes can also show this statistical regularity." But a resurgence of interest in Zipf's Law suggests something very different—namely, that Zipf was onto something rather "deep" indeed, although some refinement or modification was needed. Recent work by Ferrer i Cancho [71-73], for instance, has shown that greater effort is required by speakers, since they have to make themselves understood; whereas listeners must work harder to ensure that they interpret messages correctly. In other words, the Zipfian laws do not operate "blindly" but rather in response to communicative and other pragmatic factors.

When there are small shifts in the effort expended by speaker or hearer, changes occur cumulatively because they alter the entropy of the whole system. Interestingly, Zipfian laws have been found in other species. For example, McCowan, Hanser, and Doyle [74] discovered that Zipf's basic Law applies to dolphin communication which, like human language, had a slope of -1 ; however, in squirrel monkeys it is -0.6 , suggesting a simpler form of vocalization. As Colin Cherry [75] aptly pointed out a while back, Zipf understood the relation between form and meaning rather deeply, unlike what his critics believed. Cherry put it as follows:

When we set about a task, organizing our thoughts and actions, directing our efforts toward some goal, we cannot always tell in advance what amount of work will actually accrue; we are unable therefore to minimize it, either unconsciously or by careful planning. At best we can predict the *total likely* work involved, as judged by our past experience. Our estimate of the "probable average rate of work required" is what Zipf means by *effort*, and it is this, he says, which we minimize.

In human affairs there are always two forces at work, Zipf asserted: a social force (the need to be understood), which he called the Force of Unification and the personal force or the desire to be brief, which he called the Force of Diversification. Clearly, therefore, the implications of Zipfian analysis go far beyond the simple study of the compression of form. They imply a relation between form and meaning—a relation that generates linguistic change. What this line of research lacks, however, is the cybersemiotic view of how meaning systems involves autopoiesis and the modeling of referents in practical, yet economically-based, ways. This leads to the formulation of one other principle below.

6. The Symbolization Principle

The PLE provides a basic framework for explaining why such phenomena as alphabets have emerged and how, according to the MEP, they have led to increased knowledge-making activities. Such notions would also explain why the passage from iconicity to symbolicity has occurred, that is, from simulative forms of representation to more arbitrary conventional ones, as Brier himself has suggested in several of his key cybersemiotic studies (mentioned above). Iconic forms require the use of greater sensory effort to extract meaning from them, whereas symbolic ones simply require learned habitual processes to extract meaning from them [22]. The shift from pictography (an iconic system of representation) to alphabetical representation (a symbolic system) is a case-in-point of how this process unfolds, which can be called simply the Symbolization Principle (SP). This principle was, of course, implicit in Charles Peirce's writings. He referred to symbols as a form of "Thirdness" or the end result of iconic forms ("Firstness") gaining frequency and thus conventionality [29]. However, Peirce never really articulated this shift from iconicity to symbolicity in terms of a psychobiological framework such as the SP (at least to the best of my knowledge). The SP, arguably, allows us to get a better grasp of why symbolic codes like alphabets emerged to replace iconic ones, like pictographic ones.

The SP operates at all levels and dimensions of language. As mentioned, it can be used to explain the origin of writing as a symbolic replacement of pictography. The pictograph is a signifier designed to simulate or illustrate some referent pictorially. The earliest pictographs have been unearthed in western Asia. They are elemental shapes on clay tokens from the Neolithic era that were probably used

as image-making moulds [76-77]. They are easy to understand, but require much effort to produce. One of the first civilizations to institutionalize pictographic writing as a means of recording ideas, keeping track of business transactions, and transmitting knowledge was the ancient Chinese one [78]. According to some archeological estimates, Chinese pictography may date as far back as the fifteenth century BCE. Pictographs that encode abstract ideas are called *ideographs*. These bear resemblance to their referents, but they entail conventionalized knowledge of the resemblance pattern on the part of the user. They are generally learned in context as conventionalized forms. International symbols for such things as public telephones and washrooms today are examples of ideographs. Highly conventionalized ideographs, which tend to be combinations of pictographs, are called *logographs*.

A pictographic system was also developed by the ancient Sumerian civilization. Called cuneiform, it was an effective, but expensive and largely impracticable, means of written communication. For this reason, it was used primarily by people in authority [79]. As is well known, a pictographic script, called hieroglyphic, was also invented by the ancient Egyptians that was somewhat more practicable than the Sumerian one, because the Egyptians used it not only for inscriptions on walls and tablets, but also for recording transactions and knowledge on papyrus [80]. Some pictographic systems eventually developed phonographic elements within it—phonographs are signs standing for parts of words, such as syllables or individual sounds. Phonographic syllabaries are still used in some areas today. Japanese, for example, is written with two complete syllabaries—the hiragana and the katakana—devised to supplement the characters originally taken over from Chinese. A phonographic system for representing single sounds is called alphabetic. The first such system, which contained symbols for consonant sounds only, surfaced in the Middle East around 1000 BCE, and was transported by the Phoenicians to Greece. There, the Greeks added symbols for vowel sounds, making their writing system the first full-fledged alphabetic one.

There is little doubt that iconic (pictographic) writing gave way to phonographic-symbolic (sound) writing in the marketplaces of the ancient world because it made the writing of transactions rapid and efficient. The transition was evolutionary, that is to say, every alphabet character was the symbolic residue of an economizing alteration to an earlier pictograph. For example, the letter symbol *A* started out as a pictograph of the head of an ox which, at some point, came to be drawn only in its bare outline. The outline itself came eventually to stand for the word for ox (*aleph*). Around 1000 BCE Phoenician scribes drew the outline sideways (probably because it was quicker and “more natural” for them to do so). The resulting figure came to stand just for the first sound in the word for ox (*a* for *aleph*). Around 500 BCE, as such “abbreviated picture writing” became more standardized and letters stopped changing directions, alphabet characters emerged to form the first alphabetic code [81-83]. The Greeks started the practice of naming each symbol by such words as *alpha*, *beta*, *gamma*, etc., which were imitations of Phoenician words (*aleph* “ox,” *beth* “house,” *gimel* “camel,” etc.), and the idea of an “alphabetic order” also emerged, since the sequence of letters was used to count the numbers in order. In line with the SP, this historiography of alphabet signs implies that iconicity is involved in the initial construction of meaning, symbolism in its evolution. The move away from pictographic to alphabetic writing was, to use philosopher Thomas Kuhn’s [84] appropriate term, one of the first “paradigm shifts” in human cognitive and cultural evolution, constituting the initial event towards the establishment of a worldwide civilization based on the exchange of common symbols [85-88].

Alphabets have also made it possible to study the features of language more scientifically [89-90]. They have also had an effect on how we think and classify information. The SP is particularly evident in how language is changing in today's cyber world. Known as "Netlingo," the language of text messages, many e-mails, *etc.* can be characterized as a condensed alphabetic code with its own type of abbreviations, acronyms, and slang aimed at reducing the time and effort required to relay messages in cyberspace [91]: e.g., b4 = "before," f2f = "face-to-face," gr8 = "great," h2cus = "hope to see you soon," g2g = "gotta go," and so on. The crucial thing to note is that the characteristics of this new code are now spreading to language generally. Spelling patterns that would have been seen as improper not too long ago are now much more acceptable. It remains to be seen to what extent cyberspace will dictate the evolution of language symbolism in writing and other codes.

The SP is, fundamentally, a cybersemiotic notion because it entails a second-order process of relating form to meaning within the general entropic framework suggested by cybernetics generally. There is much work today in historical linguistics that shows a great deal of interdisciplinary and inter-theoretical approaches [92]. But, in my view, such work would gain significantly by using Brier's idea of a "second-order" system that guides change in the "first-order" one. These two reflect the two basic dimensions of semiosis—the signified and the signifier respectively. In other words, the physical models of meaning (sounds, pictographs, *etc.*) are sensitive to, and responsive to, use and intentionality. In other words, they do not operate blindly, as many working with sound change have thought. Thus, the while Zipfian approach, which is based on a first-order assessment of linguistic models, ultimately provides little insight into why the first-order modeling system changes economically. It is also at the second-order level that meaning expansion occurs as the human mind finds new uses and sees new signifying potential in the first-order models. What all this suggests, therefore, is that human systems are autopoietic, not allopoietic, and that there is a dynamic interaction between the models and their meanings and uses. What is left to do is work out the details of this interaction. This is an important task for future work.

7. Concluding Remarks

With the last consideration, it is obvious that the new science of cybersemiotics will become ever more important in studying language and other communication codes, where principles such as the MPP, MEP, and SP can be seen to operate not blindly, but interactively with human will and cognition. Above all else, this new scientific mindset provides an appropriate framework for linguists to devise other principles, such as those drafted here, to explain various modeling and diachronic phenomena. As constructs, these can then be used to guide further research, enhancing our understanding of why, for instance, languages change the way that they do and what the meaning consequences of change is. For this reason, it is my view that the cybersemiotic perspective will gain momentum as a theoretical instrument for inferring evolutionary patterns in all kinds of semiotic systems, paving the way for future development within linguistics and semiotics.

A consideration of the SP, for example, will give the current focus in Peircean semiotics, and biosemiotics generally, a sharper resolution, allowing semioticians to seek the so-called Aristotelian final causes of phenomena such as communication and change in language. Two caveats are in order. First, once we have explained linguistic change as a result of the reduction of effort and in line with

principles such as the MPP, MEP, and SP, we are still left with the problem of explaining why this is so. At this point, only speculation can be entertained. But this is the normal way of doing science. Once we have charted the manifestations of these principles, we can then confront the appearance of counter-instances—for example, language forms that are more complex than their antecedent ones. All that can be said is that the principles put forward here can be used as guides for detecting general tendencies—no more, no less. The second caveat is a corollary of the first—maybe we will end up explaining nothing, after all. Perhaps the terms “inferred” or “conjectured” are more appropriate. There really is no way to “prove” anything as being so in any absolute way. But, then again, that is what science is all about—falsification and paradigm shifting.

Weiner [93] saw the goal of cybernetics as studying how the information contained and transmitted by systems (organic and mechanical) exhibited structure. Cybersemiotics expands upon this structuralist foundation by adding the notions of autopoiesis, modelling, and their interplay with structure. Language is not just a compilation of symbols, nor is mathematics a compilation of numbers. The way these originate, used, and evolve is a result of this interplay. Human beings are not Turing machines; they are meaning-seeking organisms. Machines have no idea what meaning is; only humans do. In a fundamental way, the cybersemiotic approach is a specific realization of Gregory Bateson’s aim, contained in his *Steps to an Ecology of Mind* [94], to understand the relation mind and nature, using scientific rather than convoluted philosophical theories, such as Cartesian dualism. For Bateson, an “elementary cybernetic system with its messages in circuit is, in fact, the simplest unit of mind” [94].

To sum up, by making sign systems more compact and efficient, human beings have not restricted or diminished their ingenuity and creativity with the use of such systems. Indeed, as discussed in this paper, once new reduced forms come into existence as economic reductions of previous ones, they take on a semiotic life of their own, leading to future discoveries of meaning. This kind of assessment of change in sign systems probably characterizes how many (if not all) innovations come about in representation and communication generally. Cybersemiotic analysis, such as the one adopted here, has the capacity to show that humans, in their apparent quest for economy, end up producing new systems and serendipitous discoveries. And this is something that may defy any explanatory effort.

References

1. Chomsky, N. *Reflections on Language*; Pantheon: New York, NY, USA, 1975.
2. Chomsky, N. *Some Concepts and Consequences of the Theory of Government and Binding*; MIT Press: Cambridge, MA, USA, 1982.
3. Chomsky, N. *Knowledge of Language: Its Nature, Origin, and Use*; Praeger: New York, NY, USA, 1986.
4. Chomsky, N. *New Horizons in the Study of Language and Mind*; Cambridge University Press: Cambridge, UK, 2000.
5. Chomsky, N. *On Nature and Language*; Cambridge University Press: Cambridge, UK, 2002.
6. Lakoff, G.; Johnson, M. *Metaphors We Live By*; Chicago University Press: Chicago, IL, USA, 1980.

7. Lakoff, G.; Johnson, M. *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*; Basic: New York, NY, USA, 1999.
8. Langacker, R.W. *Grammar and Conceptualization*; Mouton de Gruyter: Berlin, Germany, 1999.
9. Fauconnier, G.; Turner, M. *The Way We Think: Conceptual Blending and the Mind's Hidden Complexities*; Basic: New York, NY, USA, 2002.
10. Brier, S. Cyber-semiotics: Second-order cybernetics and the semiotics of C.S. Peirce. Proceedings of the Second European Congress on System Science, Prague, Czech Republic, October 5–8, 1993; pp. 427–436.
11. Brier, S. Cyber-semiotics: On autopoiesis, code-duality and sign games in bio-semiotics. *Cybern. Hum. Knowing* **1995**, *3*, 3–14.
12. Brier, S. From second-order cybernetics to cybersemiotics: A semiotic re-entry into the second-order cybernetics of Heinz von Foerster. *Syst. Res.* **1996**, *13*, 229–244.
13. Brier, S. The cybersemiotic explanation of the emergence of cognition: The explanation of cognition, signification and communication in a non-Cartesian cognitive biology. *Cogn. Evol.* **1988**, *4*, 90–102.
14. Brier, S. Biosemiotics and the foundation of cybersemiotics. Reconceptualizing the insights of ethology, second order cybernetics and Peirce's semiotics in biosemiotics to create a non-Cartesian information science. *Semiotica* **1999**, *127*, 169–198.
15. Brier, S. The cybersemiotic model of communication: An evolutionary view on the threshold between semiosis and informational exchange. *Tripple C* **2003**, *1*, 71–94.
16. Brier, S. *Cybersemiotics: Why Information Is Not Enough*; University of Toronto Press: Toronto, Canada, 2008.
17. Wiener, N. *Cybernetics, or Control and Communication in the Animal and Machine*; John Wiley: New York, NY, USA, 1948.
18. Shannon, C.E. Mathematical theory of communication. *Bell Syst. Tech. J.* **1948**, *27*, 379–423.
19. Shannon, C.E. Prediction and entropy of printed English. *Bell Syst. Tech. J.* **1951**, *30*, 50–64.
20. Shannon, C.E.; Weaver, W. *Mathematical Theory of Communication*; University of Illinois Press: Chicago, IL, USA, 1949.
21. Sebeok, T.A. *Signs: An Introduction to Semiotics*; University of Toronto Press: Toronto, Canada, 1994.
22. Sebeok, T.A. *Global Semiotics*; Indiana University Press: Bloomington, IN, USA, 2001.
23. Sebeok, T.A.; Danesi, M. *The Forms of Meaning: Modeling Systems Theory and Semiotics*; Mouton de Gruyter: Berlin, Germany, 2000.
24. Barbieri, M., Ed. *Introduction to Biosemiotics: The New Biological Synthesis*; Springer: Dordrecht, The Netherlands, 2006.
25. Hoffmeyer, J. *Biosemiotics: An Examination into the Signs of Life and the Life of Signs*; Scranton University Press: Scranton, PA, USA, 2008.
26. Deacon, T. *The Symbolic Species: The Co-Evolution of Language and the Human Brain*; Penguin: Harmondsworth, UK, 1997.
27. von Humboldt, W. *On Language: The Diversity of Human Language-Structure and Its Influence on the Mental Development of Mankind*; Cambridge University Press: Cambridge, UK, 1988; p. 43.

28. von Schlegel, F. *The Aesthetic and Miscellaneous Works of Friedrich von Schlegel*; Bohn: London, UK, 1849.
29. Peirce, C.S. *Collected Papers of Charles Sanders Peirce*; Hartshorne, C., Weiss, P., Eds.; Belknap Press: Cambridge, MA, USA, 1960; Vol. 2, p. 234.
30. Saussure, F. de *Cours de linguistique générale*; Payot: Paris, France, 1916.
31. Lehman, W.P. *Pre-Indo-European*; Institute for the Study of Man: Washington, DC, USA, 2002.
32. Martinet, A. *Économie des Changements Phonétiques*; Maisonneuve & Larose: Paris, France, 1955.
33. Sapir, E. *Language*; Harcourt, Brace, and World: New York, NY, USA, 1921; p. 87.
34. Zipf, G.K. Relative frequency as a determinant of phonetic change. *HSCP* **1929**, *40*, 1–95.
35. Zipf, G.K. *Selected Studies of the Principle of Relative Frequency in Language*; Harvard University Press: Cambridge, MA, USA, 1932.
36. Zipf, G.K. *The Psycho-Biology of Language: An Introduction to Dynamic Philology*; Houghton-Mifflin: Boston, MA, USA, 1935.
37. Zipf, G.K. *Human Behavior and the Principle of Least Effort*; Addison-Wesley: Boston, MA, USA, 1949.
38. Van de Walle, J.; Willems, K. Zipf, George Kingsley (1902-1950). In *Encyclopedia of Languages and Linguistics*, 2nd ed.; Brown, K., Ed.; Elsevier Science: Oxford, UK, 2007; Vol. 13, pp. 756–757.
39. Miller, G.A.; Newman, E.B. Tests of a statistical explanation of the rank-frequency relation for Words in written English. *Amer. J. Psychol.* **1958**, *71*, 209–218.
40. Kucera, H.; Francis, W.N. *Computational Analysis of Present-Day American English*; Brown University Press: Providence, RI, USA, 1967.
41. Wyllys, R.E. Measuring scientific prose with rank-frequency (‘Zipf’) curves: A new use for an old phenomenon. *Proc. Amer. Soci. Inform. Sci.* **1975**, *12*, 30–31.
42. Rousseau, R.; Zhang, Q. Zipf’s data on the frequency of Chinese words revisited. *Scientometrics* **1992**, *24*, 201–220.
43. Li, W. Random texts exhibit Zipf’s-law-like word frequency distribution. *IEEE Trans. Inform. Theory* **1992**, *38*, 1842–1845.
44. Ridley, D.R.; Gonzales, E.A. Zipf’s Law extended to small samples of adult speech. *Percept. Mot. Skills* **1994**, *79*, 153–154.
45. Perline, R. Zipf’s law, the central limit theorem, and the random division of the unit interval. *Phys. Rev.* **1996**, *54*, 220–223.
46. Nowak, M.A. The basic reproductive ratio of a word, the maximum size of a lexicon. *J. Theor. Biol.* **2000**, *204*, 179–189.
47. Raimi, R.A. The peculiar distribution of first digits. *Sci. Amer.* **1969**, *221*, 109–119.
48. Burke, J.; Kincannon, E. Benford’s law and physical constants: The distribution of initial digits. *Amer. J. Phys.* **1991**, *14*, 59–63.
49. Hill, T.P. The first digit phenomenon. *Amer. Sci.* **1998**, *86*, 358–363.
50. Mandelbrot, B. Structure formelle des textes et communication. *Word* **1954**, *10*, 1–27.
51. Mandelbrot, B. *The Fractal Geometry of Nature*; Freeman and Co.: New York, NY, USA, 1983.
52. Danesi, M. Alphabets and the principle of least effort. *Stud. Commun. Sci.* **2006**, *6*, 47–62.

53. Gelb, I.J. *A Study of Writing*; University of Chicago Press: Chicago, IL, USA, 1963.
54. Gaur, A. *A History of Writing*; Charles Scribner's Sons: New York, NY, USA, 1984.
55. Arnheim, R. *Visual Thinking*; University of California Press: Berkeley, CA, USA, 1969.
56. Ong, W.J. *Interfaces of the Word: Studies in the Evolution of Consciousness and Culture*; Cornell University Press: Ithaca, NY, USA, 1977.
57. Harris, R. *The Origin of Writing*; Duckworth: London, UK, 1986.
58. Logan, R.K. *The Alphabet Effect*; St. Martin's Press: New York, NY, USA, 1987.
59. Coulmas, F. *The Writing Systems of the World*; Blackwell: Oxford, UK, 1989.
60. Coulmas, F. *Writing Systems: An Introduction to their Linguistic Analysis*; Cambridge University Press: Cambridge, UK, 2003.
61. Watt, W.C., Ed. *Writing Systems and Cognition: Perspectives from Psychology, Linguistics, and Semiotics*; Kluwer Academic Publishers: Dordrecht, The Netherlands, 1994.
62. Daniels, P.T., Bright, W., Eds. *The World's Writing Systems*; Oxford University Press: Oxford, UK, 1995.
63. Drucker. *The Alphabetic Labyrinth: The Letters in History and Imagination*; Thames & Hudson: London, UK, 1995.
64. Martin, H.-J. *The History and Power of Writing*; University of Chicago Press: Chicago, IL, USA, 1999.
65. Fischer, S.R. *A History of Writing*; Reaktion Books: London, UK, 2001.
66. Whorf, B.L. *Language, Thought, and Reality*; Carroll, J.B., Ed.; MIT Press: Cambridge, MA, USA, 1956.
67. Brown, R. *Words and Things: An Introduction to Language*; The Free Press: New York, NY, USA, 1958; p. 235.
68. Miller, G.A. *Language and Communication*; McGraw-Hill: New York, NY, USA, 1951.
69. Miller, G.A. *Language and Speech*; W. H. Freeman: New York, NY, USA, 1981; p. 107.
70. Lucy, J.A. *Language Diversity and Thought: A Reformulation of the Linguistic Relativity Hypothesis*; Cambridge University Press: Cambridge, UK, 1992.
71. Ferrer i Cancho, R.; Sole, R.V. Two regimes in the frequency of words and the origins of complex lexicons: Zipf's Law revisited. *J. Quant. Linguist.* **2001**, *8*, 165–231.
72. Ferrer i Cancho, R. The variation of Zipf's Law in human language. *Eur. Phys. J.* **2005**, *44*, 249–257.
73. Ferrer i Cancho, R.; Riordan, O.; Bollobás, B. The consequences of Zipf's Law for syntax and symbolic reference. In *Proceedings of the Royal Society of London, Series B, Biological Sciences*; Royal Society of London: London, UK, 2005; pp. 1–5.
74. McCowan, B.; Hanser, S.F.; Doyle, L.R. Quantitative tools for comparing animal communication systems: Information theory applied to Bottlenose dolphin whistle repertoires. *Anim. Behav.* **1999**, *62*, 1151–1162.
75. Cherry, C. *On Human Communication*; MIT Press: Cambridge, MA, USA, 1957; p. 103.
76. Schmandt-Besserat, D. The earliest precursor of writing. *Sci. Amer.* **1978**, *238*, 50–59.
77. Schmandt-Besserat, D. *Before Writing*; University of Texas Press: Austin, TX, USA, 1992; Vol. 2.
78. Billeter, J.F. *The Chinese Art of Writing*; Rizzoli: New York, NY, USA, 1990.

79. Walker, C.B.F. *Cuneiform*; University of California Press: Berkeley, CA, USA, 1987.
80. Davies, W.V. *Egyptian Hieroglyphs*; University of California Press: Berkeley, CA, USA, 1988.
81. Driver, G.R. *Semitic Writing: From Pictograph to Alphabet*; Oxford University Press: Oxford, UK, 1976.
82. Robinson, A. *The Story of Writing*; Thames and Hudson: London, UK 1995.
83. Samoyault, T. *Alphabetical Order: How the Alphabet Began*; Viking/Penguin: New York, NY, USA, 1988.
84. Kuhn, T. *The Structure of Scientific Revolutions*; University of Chicago Press: Chicago, IL, USA, 1962.
85. McLuhan, M. *The Mechanical Bride: Folklore of Industrial Man*; Vanguard: New York, NY, USA, 1951.
86. McLuhan, M. *The Gutenberg Galaxy: The Making of Typographic Man*; University of Toronto Press: Toronto, Canada, 1962.
87. McLuhan, M. *Understanding Media: The Extensions of Man*; MIT Press: Cambridge, MA, USA, 1964.
88. McLuhan, M.; McLuhan, E. *Laws of Media: The New Science*; University of Toronto Press: Toronto, Canada, 1988.
89. Illich, I.; Sanders, B. *The Alphabetization of the Popular Mind*; North Point Press: San Francisco, CA, USA, 1988.
90. Man, J. *Alpha Beta: How 26 Letters Shaped the Western World*; John Wiley & Sons: New York, NY, USA, 2000.
91. Crystal, D. *Language and the Internet*; Cambridge University Press: Cambridge, UK, 2001.
92. Joseph, B., Janda, R., Eds. *The Handbook in Historical Linguistics*; Blackwell: London, UK, 2003.
93. Wiener, N. *The Human Use of Human Beings: Cybernetics and Society*; Houghton Mifflin: Boston, MA, USA, 1950.
94. Bateson, G. *Steps to an Ecology of Mind*; Ballantine: New York, NY, USA, 1972; p. 459.

© 2009 by the authors; licensee Molecular Diversity Preservation International, Basel, Switzerland. This article is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/3.0/>).