

The Evolution of Language as the Interface for Cultural and Technological Progress

Ella R. Hough

College of Arts & Sciences, Cornell University

COGST 4270 Evolution of Language



December 19, 2024

Introduction

“Human societies exhibit a great variety of technological, agricultural, and economic complexity, but no group of humans anywhere in the world has ever been encountered without a language” (Christiansen & Chater, 2022, 11).

Language is humanity’s first true interface of reality. An interface is a tool for interaction such as by perceiving, by interacting with, or by exchanging information. Language is humanity’s first true tool to understand and engage with the world, with reality, and it has evolved, with feedback loops, to amplify cultural and technological progress. This statement is substantial and, on first read, might seem false. To read this statement, one needs to use their eyes. Arguably, they are interfacing with reality through sight, not language. The same logic might be applied for the other senses of hearing, smell, taste, and touch. However, these five senses all fail to be an interface such as language in that they are largely receptive and reactive, not proactive and interactive. While senses observe, language bridges and materializes observation into communication. While senses observe reality, language shapes reality, influencing thought, perception, and action, laying the foundation for cultural transmission and technological innovation. In their 2018 paper, Dediu and Levinson note that “language affords culture-carrying capacity (e.g. there are not advanced technologies without language),” and “language seems to be a precondition for the transmission of elaborate lithic technologies [stone tools]” (Dediu & Levinson, 2018, 52-53). More tangibly, in his TEDx Talk, author Phuc Tran shares that “grammar is your first and most powerful tool to experiencing and communicating the world around you,” presenting results from a 2011 Gallup International survey of different nations’ feelings of optimism. Vietnam, a country without a subjunctive tense, or the ability to express regret (e.g. could’ve or should’ve), was the most optimistic country, and France with two subjunctive tenses was the most pessimistic country (Tran, 2012). Further, studies done at the University of Wales at Bangor and Humboldt University showed that language does in fact affect how we see the world (Christiansen & Chater, 2022, 84). These three examples demonstrate how “language shapes which thoughts are natural, but not which thoughts are possible,” highlighting a solution to the debate of the “Sapir-Whorf hypothesis, which states that language can shape and determine thought (Christiansen & Chater, 2022, 85). With these examples in mind, it is now less of a jump to understand how language has led to the evolution of culture, “cataly[zing] explosive change in almost every aspect of human culture and society” (Christiansen & Chater, 2022, 82).

Language is a protocol, a catalyst, and a system of communicating meaning. On this account, there are more languages than just spoken languages of how humans interface with reality, and as the evolution of language shows us, language was not always spoken. On this account, math is an instantiation of language, writing is an instantiation of language, code is an instantiation of language, and money is an installation of language. They are all methods of human communication. They embrace the cognitive and social abilities of humans and they embody the flexibility, diversity, and ingenuity that makes human language, human's communication system, unique from non-human communication systems. Critically, as language evolves, endowing its speakers with a better tool and greater abilities, its creations also feed into itself, furthering its own evolution. Reflecting on the impact of language thus far, *"...language likely transformed our species by enabling cross-generational transmission of acquired knowledge...The cumulative effect of this transmission...along with increased sophistication of our social and problem-solving abilities is plausibly what enabled us to create human civilizations...[,and] it is unlikely that our species' success would have been possible without the cumulative culture that was enabled by the external use of language"* (Fedorenko et al., 2024, 583). Considering future transformations of the continued evolution of language, it is prudent to think about what "increased sophistication" language evolution has enabled and the feedback loops that have arisen.

To do so, this paper will begin by addressing essential background information, grounding later arguments. First, the author's view on three prominent discussions in the conversation of the evolution of language: language as uniquely human, language as a tool for communication, and language evolution as a mix of biological and cultural influences will be shared. Next, three frameworks to consider evolution, innovation, and transitions through society will be discussed. Finally, six cases of innovations intersecting the paradigms of linguistic, cultural, and technological evolutions will be presented through the number zero, writing, the printing press, code, the internet, and bitcoin. Notably, predominantly, the number zero and bitcoin are presented as uniquely foundational discoveries while writing and code are presented as linguistic evolutions amplified by technological evolutions in the printing press and the internet. The paper concludes with a message of hope regarding language as humanity's continued best tool to interface with uncertainty and evolution.

Background

1. Language vs. Communication | Language is Uniquely Human

Critically, there is a distinction between “communication” and “language.” In their book, *The Language Game*, Christiansen and Chater describe how communication, which “may be as old as life itself,” beginning with “quorum sensing” in archaea, “primitive unicellular organisms that have no cell nuclei,” “may be universal across species, but language is uniquely human” (Christiansen & Chater, 2022, 169 & 191). Their rationale for language being uniquely human lies in its flexibility, diversity, and ingenuity. For instance, across species from bacteria to plants to bees to cuttlefish to monkeys, dictated by their genes, members communicate in the same manner, yet within humans, 7,000 different languages exist, varying in every way, and each language is susceptible to evolution through cultural forces. (Christiansen & Chater, 2022, 176).

As a tangible example, while East African Vervet Monkeys have three precise alarm calls for carnivores such as leopards, aerial predators such as eagles, and snakes, human language has a “lightness of meaning” to it, indicating that meaning comes not from the call or word itself, but rather from the context it is used in, highlighting its ingenuity (Christiansen & Chater, 2022, 171-172).

Finally, as a precise list, in the 1950s and 60s, linguist Charles Hockett compiled a list of sixteen features, which all human languages share but not all animal communication systems share: vocal-auditory channel, broadcast transmission and directional reception, rapid fading, interchangeability, total feedback, specialization, semanticity, arbitrariness, discreteness, displacement, productivity, traditional transmission, duality of patterning, prevarication, reflexiveness, and learnability (Sedivy 2020, 13). Notably, his features are contested, yet joint attention (awareness between two or more individuals than they are paying attention the same thing), arbitrariness, generativity, displacement, and reflexiveness are most important and are uniquely present in human language as a result of social and cognitive abilities (Waciewicz et al., 2014; Sedivy, 2020, 22; Cuskley, 2020, 2).

2. Language is a Tool for: Communication or Thought?

While language is different from communication, language is a tool for communication rather than thought. Language is a foundation for collaboration amongst interlocutors familiar

and unfamiliar. While it is not a definite fact, language likely first evolved between 2,000,000 to 200,000 years ago, and today, there are about 7,111 languages in existence (Wong et al., 2020, 1; Cuskley, 2020, 3). Most often, when one thinks of language, they think of spoken language; however, “gesture-first” rather than “vocalization-first” theories of language evolution are becoming more prominent (Macuch et al., 2020; Cwiek et al., 2021; Levinson, 2016), such as Christiansen & Chater’s “Language as Charades” theory (Christiansen & Chater, 2022). For further context, “spoken and signed languages predate written language by at least hundred of thousands of years” (Cuskley, 2020,1). Notably, highlighting the feedback loops between language, culture and technology, human’s capacity for spoken language perhaps began as a result of agricultural innovation in the Neolithic. As predominantly hunter-gatherers during the Paleolithic, humans’ natural overbite or overjet evolved to an edge-to-edge bite configuration, as a result of excessive chewing of harder foods (Blasi et al., 2019). However, a rise in food processing, meaning softer diets, led to a preservation of humans’ natural bite configuration, facilitating greater innovation in speech sounds and an increase in humans’ ability to produce spoken communication (Blasi et al., 2019). Interestingly, also tied to agriculture, humanity’s 7,000 languages are disproportionately found around the world with the majority in tropical zones (Christiansen & Chater, 2022, 182). Humans in cold zones experience less food security and benefit more from a shared language to facilitate trade (Christiansen & Chater, 2022, 183).

The idea of trade is critical for evaluating if language evolved for communication or thought. Outside of just goods and evaluating against other species, “...humans are inclined to share information with one another, whereas other primates seem not to have discovered the vast benefits of doing so...in fact...in comparison to...the life of chimpanzee...human experiences are shaped very profoundly by a layer of social reality” and “being able to take part in complex social activities that rely on mutual coordination is closely tied to the emergence of language” (Sedivy, 2020, 20-21 & 25). Further embodying this sentiment, in their respective papers, Bickel et al. share that historically, languages have functioned as “markers of trust” and “cooperation networks,” Raviv et al. consider if “languages evolved...for social coordination,” and Fedorenko et al. assert “...language serves a primarily communicative function (Bickel et al., 2024; Raviv et al., 2019; Fedorenko et al., 2024, 583). Bickel et al. also goes one step further saying, “no matter which language we look at, the faculty of language enables open-ended communication, creative cognition, and richly structured cooperation...at the same time the

faculty is fundamentally dynamic...linguistic evolution follows from the social function of language: languages diversify in response to social clustering, providing ubiquitous, continuously updated identity markers and creating a sense of belonging” (Bickel et al., 2024, 213).

Notably, language is not a tool for communication in alignment with current theories of communication such as Claude Elwood Shannon’s “transmission model of communication.” Under this model, what is considered is the successful passive transmission of information packets without concern to meaning. However, meaning is essential to successful human language exchanges and “viewing language as charades, a collaborative game of improvisations” where one could draw on “The Communication Iceberg” reflects the uniqueness of human language and its true communicative abilities. If language were viewed under the transmission model of communication, in 1769 when Captain Cook and the Crew of the *HMS Endeavour* arrived at the Bay of Good Success on Tierra del Fuego in South America, they would have no way to decode the Haush hunter-gatherers’ message and vice versa (Christiansen & Chater, 2022, 9). However, when the Haush threw down their sticks, the crew could improvise, drawing on their Communication Iceberg and recognizing this was a gesture of peace (Christiansen & Chater, 2022, 9). Going past the viewing of sticks being dropped (the information itself), this example highlights how human communication, language, is entirely about the contextual meaning and can enable trust between groups without a shared background.

3. Evolution of Language: Biological or Cultural? Nativist or Anti-Nativist?

To put it very simply, it is unlikely the evolution of language is purely biological as Stuart Little, the talking mouse, only exists in the movies, indicating there is no “language gene” such as FOXP2. Further, some have posited that the Baldwin Effect, which describes how “traits acquired in development may become genetically encoded through the selection of better learners” could “underpin the evolution of a genetic blueprint for language” (2150 Lecture Slides, W9-1). However, this is likely incorrect as human evolution is on the order of millions of years while language evolution is on the order of thousands of years, meaning that language changes faster than biology (2150 Lecture Slides, W9-1). Finally, there is not one innate universal grammar used to acquire language as Noam Chomsky suggested (2150 Lecture Slides, W7-1). Noam Chomsky sought to place language in the context of math and science instead of

culture, forming a generative grammar, universal grammar, through math, free of ambiguity and flexibility. Chomsky believed children could not learn patterns from experience and that patterns are built into the brain, that language is in our genes from the outset (*2150 Lecture Slides*, W7-1).

As the Cook-Haush example highlights, culture has an impact on language. The Connectionist Model shows that children are not born with an innate universal grammar. Rather, a construction grammar which relies heavily on chunks and the Communication Iceberg to acquire and produce language that gets through the Now-Or-Never-bottleneck is more likely. For instance, children initially saying “me do it” instead of “let me do it” highlights the evolution of acquiring language through constructions (Christiansen & Chater, 2022, 40). Further, language evolves by and with each generation, following the footsteps of those that preceded them and paving the way for those that will succeed them. Each generation has to learn the patterns of language from yesterday’s learners; words are just clues, and “the interpretation of today’s clues depends on the interpretation of yesterday’s clues so that linguistic conventions gradually emerge” (Christiansen & Chater, 2022, 58). Additionally, language learning is a problem of cultural world C-learning, not natural world N-learning. Just as ponds don’t learn the theory of wave motion to ripple, they just do through the impact of their environment, children learn language through their community (*2150 Lecture Slides*, W12-2; Christiansen & Chater, 2022, 62).

However, just as language evolution is not biological, it’s also not purely cultural. Rather, it is more likely that language evolution is influenced by both biological and cultural evolution (Christiansen & Chater, 2022; Fagot et al., 2019). Consider “language [as] a communicative tool shaped by our brains, just as physical tools, like forks, saws and spades, have been perfectly shaped by cultural evolution to fit our hands, legs, and body (Christiansen & Chater, 2022, 143). For another analogy, just as Charles Darwin’s theory of evolution by natural selection showcases “survival of the fittest traits” in an environment, the culture evolution theory of language showcases “survival of the fittest words” given human brains. Languages are not innate, rather they exist because humans can learn, produce, and pass them on, which is the perspective of an anti-nativist. Nativists, on the other hand, “argue that children are innately outfitted with a universal grammar” and believe the “human mind has changed over time so as to adapt to the forms and structures that occur in human languages” (Sedivy, 2020, 56).

Frameworks

1. Evolution

With a firm grasp on the uniqueness of language, language’s difference from communication, and language’s biological and cultural evolution, it will now be beneficial to explore the framework of language evolution in comparison to that of biological evolution and cultural (technological) evolution as this paper is exploring the feedback loops between language, culture and technology and “cultural evolution impacts language [rapidly]” (Bickel et al., 2024, 211). To begin, Bickel et al. note that “all modes of evolution rely on the same core process: a mechanism producing variation (“mutation,” “change”) and a mechanism transmitting this variation (“inheritance,” “learning”), potentially with reduction (“selection,” “drift,” “bias”) (Bickel et al., 2024, 212). More specifically, they reveal “three dimension[s] in which modes of evolution different from each other: whether evolution is ergodic or novelty-driven, whether or not is requires vertical transmission, and whether it rests on one or two physical substrates,” caveating “the three dimensions lead to a richer space of possibilities” (Bickel et al., 2024, 221). The three modes of evolution evaluated can be viewed along the above three dimensions in the following chart.

	Ergodic or Novelty-Driven?	Requires vertical transmission?	One or Two Physical Substrates?
Biological	Phenotypic novelty and stability (Bickel et al., 2024, 215).	Yes.	1) selection: phenotypes & 2) variation and inheritance: genotype (Bickel et al., 2024, 216).
Cultural (In particular, technological)	Novelty and stability (Bickel et al., 2024, 215).	No.	1
Linguistic	Leads to ergodicity & stationarity (Bickel et al., 2024, 215).	Yes to some extent.	1

Biological: Variation is produced in biological evolution through novel (new) traits which stabilize over time and this variation is transmitted vertically from generation to generation. Uniquely from cultural (technological) and linguistic evolution, the selection and

inheritance of variation occur in two different substrates, the phenotype (observable) and genotype (not observable), respectively. **Cultural (Technological):** Variation is produced in cultural (technological) evolution through an “alteration between stable solutions and radical, discovery-driven innovations in specific utility niches” (rather than falling back to a previous state) and “tend toward ever growing and cumulative complexity” (Bickel et al., 2024, 215). For instance, think of the evolution from the wheel to the engine. Uniquely from biological and linguistic evolution, technological evolution can pass within and between generations. Further, unlike biological evolution, the selection and inheritance of variation occurs in just one substrate (the physical technology such as the wheel or the engine). **Linguistic:** Variation is produced in linguistic evolution through ergodicity, meaning it cycles through similar patterns rather than becoming increasingly complex like in technological evolution. While linguistic evolution is predominantly transmitted vertically across generations, there are some horizontal transmissions (ex: slang, abbreviations, or cultural references). Further, because linguistic variation also only has one substrate (language itself) it allows for “deliberat[e] and biased change” from cultural impacts (Bickel et al., 2024, 211).

2. Innovation

The ability to evolve implies the ability to innovate. Language, culture, and technology have all evolved and, in doing so, represent transformational innovations. And, these are not siloed innovations. Interfacing with each other, they progress and evolve each other, together. Language was an adaptive discovery, an adaptive innovation. Language improves upon existing tools for communication and is influenced by the social and cultural, cognitive, and technological abilities and achievements of its host (humans).

Language is a peer-to-peer, decentralized, permissionless, and open-source innovation. In opposition to the nativist “centralizing” view of language origins, language has evolved in a decentralized manner. For instance, in 1668, John Wilkins sought to create a “perfect language;” however, by aligning letters or sounds with meaning so precisely, he made the language utterly unusable (History of Information; 2150 Lectures Slides, W6-2). In reality, in spoken languages, we have “onomatopoeia” - words remind us of things they refer to and the arbitrariness that we find in links between sign and meaning is not an imperfection but a crucial strength (2150 Lecture Slides, W6-2) of language). Each of the eight billion people on this earth have a lived

experience and “Communication Iceberg” that cannot be centrally planned. Further, the ideas of joint action and social coordination, peer-to-peer exchange are central to its evolution and use. Language does not require an invitation to use and with only one substrate, it’s “open-source” for anyone to adapt, edit and change. “No one planned language. The complexity and order of language emerge from the chaos of countless games of linguistic charades...in a very real sense, the most important human invention is an accumulation of accidents” (Christiansen & Chater, 2022, 34).

Innovation does not emerge through creation alone; innovation needs distribution. Notably, like language, the most transformational innovations thus far, such as the number zero, the alphabet, and writing systems, were spread on a peer-to-peer (P2P) basis (often through trade routes) and are decentralized, permissionless, and open-source. They were distributed through humanity, through human community interaction. Community is society’s greatest technology and language is how we build it, engage it and preserve it. Community is the common thread of language, culture, and technology, facilitating feedback loops of transformation and innovation through these protocols which enable collective societal coordination and evolution. As Christiansen and Chater note, “it is through the invention of linguistic charades, and the virtuous cycle of language, culture, and the brain that it triggered, that humans have come to dominate the entire planet” (Christiansen & Chater, 2022, 86). Further, this cycle of innovation through language has been so transformative that geologists announced a “new geological epoch - the Anthropocene - in recognition of humanity’s collective and often profoundly disruptive influence” (Christiansen & Chater, 2022, 86).

3. Transitions

Before diving into how language has amplified human progress, preserving and distributing knowledge, resulting in transformative cultural and technological innovations, which reflexively influence the evolution of language, it would be prudent to discuss *that* the evolutionary transition of language has amplified human progress and is observed in all cycles of change in our world.

Mark Moss describes how political/social/cultural cycles, financial cycles and technological cycles occur and overlap throughout history (Moss, The Investor’s Podcast Network). Political/social/cultural revolutions occur every ~250 years with populous uprisings

every ~84 years. Financial cycles occur every ~80 years, and technological cycles occur every ~50 years (Moss, The Investor's Podcast Network). 264 years ago, the Industrial Revolution ended. 80 years ago, the Bretton Woods Agreement was signed, pegging all currencies to the dollar, which until 1971 was backed by gold. 50 years ago, the first personal computer was born, and it's been 41 years since the birth of the internet. Throughout these cycles we swing from systems of centralization to decentralization; currently, the pendulum is swinging towards decentralization and away from centralization (Moss, The Investor's Podcast Network).

This is relevant to highlight for three reasons. First, language interfaces with and mediates every one of these cycles. Second, according to evolutionary biologists John Maynard Smith and Eörs Szathmáry, “the eighth and final major transition in the history of evolution... is the emergence of language” (Christiansen & Chater, 2022, 86). Third, perhaps unsurprisingly, just as reality has patterns, “it is the systematic patterns in language...that give it such power...to transform our collective ability to create new forms of cultural, technological, and social complexity...Indeed, the eighth evolutionary transition is really not just one transition but a cascading wave of transitions” (Christiansen & Chater, 2022, 86). With these reasons in mind, when thinking about implications of the future of language evolution, it is prudent to think about what language evolution has influenced and the feedback loops that have arisen. One such influence that has had powerful ripple effects across time is that of the number 0.

Cases

1. The Number Zero

Within non-human species, communication is largely understood by all members. For instance, through their “waggle dance,” bees can communicate the quality, direction, and distance of a food source or where to build a nest, and through their “thirty-four chromatic patterns of skin coloration,” cuttlefish can communicate courtship or discretion (Christiansen & Chater, 2022, 68-69). The 7,000 languages of humans’ linguistic diversity is a “feature, not a bug,” yet there are two vital universal languages: math and money.

To begin, math is a language of numerals and “the invention of the written symbol for zero” by Brahmagupta in the 7th century (628 CE) fundamentally reshaped it (Christiansen & Chater, 2022; Breedlove, 2020; Szalay, 2017). Math as a language evolved from the energy

inefficient base-60 Babylonian cuneiform system, Ancient Greek and Mayan numeral systems, and Roman numeral system to the energy efficient Hindu-Arabic numeral system with the advent of zero along trade routes (Breedlove, 2020). Zero is an interface that fundamentally reshaped how humanity acted on and engaged with culture and technology. Zero represents “nothingness,” yet its masterful ability to abstract was transformational for our language of math today and lies in the basis of most everything. As such, understanding the implications of the evolution language in terms of zero on language, technology and culture is where this paper will start.

On the technological front, zero completed the number line and allowed numbers “to be used again and again with different meanings for different purposes” and gave way to “imaginary numbers, complex numbers, fractals, and advanced astrophysical equations” (Breedlove, 2020). From this, zero was instrumental to the development of calculus, underlying “the mathematical machinery on which much of the physical sciences, and, thus, the modern world are constructed” (Breedlove, 2020). Two such examples are zero’s influence on Nicolaus Copernicus’ Copernican heliocentrism in 1543 and encryption systems in 1299 when the Hindu-Arabic numeral system was banned in Florence as “cipher” originally meant “zero” (World History Encyclopedia; Breedlove, 2020). In modern day, zero through binary code has contributed to the evolution of communication protocols in the internet and the computer (Breedlove, 2020). However, zero has influenced more than the eye can see, literally.

Culturally, by allowing for the concepts of nothingness, infinity, ratios, and fractions, zero influenced humanity’s ability for a “logic-based way of thinking at the root of major social movements such as the” Renaissance in the 14th - 16th centuries, the Reformation in the 16th - 17th centuries, and the Enlightenment, containing the Scientific Revolution, in the 17th - 18th centuries (Britannica (b); Mark, 2021; Britannica (a); Breedlove, 2020). Zero “as an artistic tool to create the vanishing point..sparked the great Renaissance in the visual arts” (Breedlove, 2020). Then, influenced by altered perception through art, Cardinal of the Church, Nicholas of Cusa’s declaration that “the Earth is not the center of the universe” lead to Copernicus’ proving of heliocentrism, sparking the Reformation and Enlightenment (Breedlove, 2020).

What can be drawn from above, representing the lightness of meaning in language, zero was not simply a marking of “nothingness” or a bridge from positive to negative numbers, rather, zero’s meaning came from the context of its use. For instance, following a thought experiment of numbers as the basis, and drawing on the scientific concepts of transitivity, there is an

unconventional connection that $E = mc^2$ is equal to $A = \pi r^2$ (Dunworth). Ultimately, zero's arbitrariness, ingenuity, and versatility and additional embodiment of generativity, displacement, and reflexiveness "lead to enhanced informational exchange and its associated development civilizational advances," amplifying knowledge systems just as we see in language as traditionally defined (Breedlove 2020).

2. Writing

"Language, as it turns out, is not at all the same thing as speech and can exist independently of it," yet "one of the great challenges facing the study of language evolution is that language itself leaves no fossils (given that language surely arose long before writing systems" (Sedivy, 2020, 36 & 51-52).

Language is humanity's most resilient technology for data abstraction, incredibly hard to disrupt. For the past 3,000 years, humans have used the same alphabet, and for 5,000 years prior to that, humans communicated via the same clay token system (Schmandt-Besserat, 2014). Through this staying-power, "language has allowed [humanity] to harness the accumulated insights of countless generations[, underpinning] most aspects of abstract thought - about mathematics, science, technology, the law, or any other domain - with far-reaching implications for the development of our culture and society" (Christiansen & Chater, 2022, 86).

However, critical for humanity's dominance and reception of the full benefits of language is the advent of writing. George Bernard Shaw's quote, "If you have an apple and I have an apple and we exchange these apples then you and I will still each have one apple. But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas" is well known. Writing is how these ideas transcend generations. Across generations, writing ensures oral exchange is not like that of apples but rather like the exchange of ideas. And, writing is how we grow ideas in ourselves; it's how this paper and its ideas were formed.

In their recent paper, Bickel et al. note that "the earliest transition of language into evolving technology came with writing" (Bickel et al., 2024, 221). Further, in a 2014 paper, Schmandt-Besserat shares, "writing is humankind's principal technology for collecting, manipulating, storing, retrieving, communicating and disseminating information" (Schmandt-Besserat, 2014). In alignment with "gesture-first" and "communication rather than thought" theories of language evolution, writing was preceded by clay tokens as "a system for

counting and recording goods” in trade from 8000 - 3500 BC (Schmandt-Besserat, 2014). The need for writing as we think of today arose when these tokens needed to be stored, perhaps representing a debt. Concealed in a hollow envelope, the tokens were first imprinted on the outside, abstracting the information of debt from 3D to 2D, creating writing. Eventually, just tablets with markings were used and the tokens were no longer necessary. Then, evolving for needs outside of accounting, at the formation of the state and increased regulation, in its second evolution in 3000 BC in Mesopotamia, writing evolved to include phonetic signs to record names attached to merchandise or on tombs. Finally, in 1500 BC, writing’s third evolution included the alphabet. Critically, Phoenician merchants brought the alphabet to the Greeks around 800 BC, “who perfected the Semitic alphabet by adding letters for vowels—speech sounds in the articulation of which the breath channel is not blocked, like a, e, i, o, u[, and a]s a result the 27-letter Greek alphabet improved the transcription of the spoken word, since all sounds were indicated” (Schmandt-Besserat, 2014). Writing was instrumental to the evolution of language, but spoken and written language work in tandem as “the alphabet consists of semantically meaningless letters corresponding to semantically meaningless sounds” and “phonetics allowed writing to shift from a representational to a conceptual linguistic system[,] enabl[ing] writing to leave the realm of real goods in order to enter the world of words and the ideas they stand for” (Schmandt-Besserat, 2014). However, ideas have not always had the necessary infrastructure to stand, especially the test of time.

Language evolution is tightly interconnected with technological innovation and arguably the next two great evolutions were in terms of its means of distribution, which drastically impacted cultural evolution as well. First, “the printing press invented in 1450 dramatically multiplied the dissemination of texts, introducing a new regularity in lettering and layout” (Schmandt-Besserat, 2014). Second, “the internet catapult[ed] the alphabet into cyberspace” and amplified the effects of the printing press (Schmandt-Besserat, 2014). However, thinking along Bickel et al.’s core processes of evolution, writing as a technology is “driven by cultural rather than linguistic evolution.” Horizontal transmission “allows communication across arbitrary distances, to millions of people world wide and simultaneously, and without identifying ourselves as the source” and is not ergodic (Bickel et al., 2020, 221). These realities are seen in the printing press and the internet. And, while knowledge was first abstracted in the form of

thoughts in people's heads, or at the decree of the Church, now knowledge could be put physically in the hands of people.

3. The Printing Press

Communication is the basis of transitions in society. So much so that in 1675, King Charles II attempted to ban coffee houses as they were forums of discussion, “help[ing] spread modern democracy, spur the Enlightenment and birth periodical literature” (El-Beih, 2020). However as can be garnered from King Charles II's reaction, it isn't so much the speech itself that matters, but rather its distribution. For instance, consider the classic thought experiment: "If a tree falls in a forest and no one is around to hear it, did the fall make a sound?" Distribution of communication, visual or aural, matters. If we reflect on the evolution of the dissemination of language and communication through technology from tablet ledgers → papyrus paper → manually copying books → the printing press → telegraph → newspapers → internet, in each wave, the number of people who could participate in creating communication increased, which led to the collapse of the dominance of institutions and changed how power worked in society (Rabble, 2024). The printing press was a particularly revolutionary communication technology, amplifying what the number zero sparked. While the printing press was initially supposed to be a technology to bring a centralized view (the Bible) to many, actually, in a peer-to-peer manner, it brought a decentralized idea to many.

As with the evolution of writing, one of the earliest forms of printing (block printing) was located in China with the “*The Diamond Sutra*...from around 868 A.D. during the Tang Dynasty [considered the] oldest known printed book” and Wang Chen's 1297 book on agriculture, *Nung Shu* is considered the world's first mass-produced book” (History.com Editors, 2024). On the technological front, in ~1436 Johannes Gutenberg's printing press improved upon past models, replacing wood with metal, making his own ink to better stick to the metal, and perfecting how to flatten the paper (Roos, 2023; History.com Editors). Notably, “the key innovation in printing [was] the precise combination of metal alloys and [Gutenberg's] process used to cast the metal type: “a screw-type wine press to squeeze down evenly on the inked metal type” (Dittmar, 2011; Roos, 2023). Additionally, the printing press “helped create a more uniform language,” “minimized [monk copying] error,” increasing literacy and accuracy of knowledge, furthered education and legal disciplines, and “was also associated with the diffusion of cutting-edge

business practice (such as book-keeping)” (Osei-Hwere & Osei-Hwere; Dittmar, 2011). As trade impacted the evolution of writing, trade also impacted the evolution of skill development and what was printed. Notably, the first math textbook from 1478, the *Treviso Arithmetic*, reads: “I have often been asked by certain youths...who look forward to mercantile pursuits, to put into writing the fundamental principles of arithmetic” (Dittmar, 2011, 1136-1137). And finally, “the printing press introduced the world to the idea of machines” perhaps influencing the groundwork of the Industrial revolution (Roos, 2023).

On the cultural front, from data of 200 European cities, the technological evolution of the printing press resulted in a 60% increase in economic growth across cities that adopted it from 1450 -1600 (Dittmar, 2011). The printing press impacted the creation of “new professionals – merchants, lawyers, officials, doctors, and teachers” (Dittmar, 2011) and increased collaboration, especially amongst scientists and researchers, amplifying the Renaissance and leading to the Scientific Revolution and Enlightenment (Osei-Hwere & Osei-Hwere). Diving deeper, it “fostered important face-to-face interactions [because] the printer’s workshop brought scholars, merchants, craftsmen, and mechanics together for the first time in a commercial environment, eroding a pre-existing “town and gown” divide (Dittmar, 2011). Further, by lowering the cost to share ideas and democratizing knowledge, the printing press “changed the consumption of news” through short pamphlets as seen in Venice (Roos, 2023). On an even more extreme note, in his book *The Gutenberg Galaxy*, Canadian philosopher Marshall McLuhan “argued that movable type effectively rewired human cognition and paved the way for such large-scale trends as nationalism” (Smith, 2016).

While the printing press is most often cited in regards to the Protestant Reformation, just as the printing press could amplify Martin Luther’s voice, it also could amplify any voice on “the fringe” (Roos, 2023). Historian Ada Palmer shares that “whenever a new information technology comes along...among the very first groups to be ‘loud’ in it are the people who were silenced in the earlier system” (Roos, 2023). And, with the printing press, an idea could no longer die with its holder, preserving and efficiently replicating knowledge, the printing press made it hard if not near impossible to kill an idea. Ultimately, across its impacts on technological and cultural evolution, Dr. Elizabeth Eisenstein notes that the printing press was “an agent of change” and a “communications revolution” (Smith, 2016). As with the evolution of language through the printing press and the number zero, these evolutions became an interface for greater cultural and

technological progress, which then cyclically led to the further evolution of language. Four to Five centuries after the evolution of (written) language through the printing press, another communications revolution occurred in the birth of computer programming languages and the internet.

4. Code

A 2017 study found that of the 3,200 18 - 34 year-olds across the US, UK, France, Germany, Japan, and Australia surveyed, 65% communicated more digitally than physically and 69.4% preferred a messaging app over the phone app (Bradbury, 2018). With the advent of technology, the catalyst of human communication is changing, but the origins of this evolution is largely the same (scaled exchange) as that seen from writing to the printing press and the number zero continues to be at the heart of this evolution of language (of computers).

While much credit goes to Gottfried Wilhelm Leibniz for the discovery of binary in 1701, current scholarship shows Thomas Harriot discovered binary around 1604-1605, but his manuscripts were not discovered until 1922, and Juan Caramuel de Lobkowitz re-discovered binary in 1670, which was plagiarized by Leibniz (Ares et al., 2018; Strickland 2024). Interestingly, Harriot didn't think much of his discovery and came upon binary through measuring weights (Strickland 2024). As the saying goes, "nothing in this world is so powerful as an idea whose time has come" and binary's time came when this technology's linguistic evolution interfaced with cultural evolution during World War II. In 1843, Ada Lovelace created the first computer program, which birthed the idea of programming languages. After seeing Charles Babbage's presentation of his "Difference Engine" in 1833 and his use of punch cards in his "Analytical Engine" a decade later, Ada saw striking similarities to the weaving mechanism of the Jacquard loom for textiles, varying from "hole" or "no-hole," instantiated by "zero" or "one." Connecting these dots, Ada set the foundation for the binary code we use today (Hessler, 2023). However, it was not until 1936 when Alan Turing, who cracked the Enigma machine, conceptualized a machine which could follow instructions, a machine that could be programmed, until binary code took off with the first programming language created in the 1940s (Hierso, 2022). Notably, the first general-purpose computer (ENIAC) in 1946 did not use binary code (Brockmeier, 2011). Today, binary code is used because it allows computers to store data in a way that they can still interact with their hardware and be turned off (0) or on (1). However, as

human language is shaped by the brain, programming languages evolved from binary as they are also shaped by the brain (and the computer). Just as human languages better survive and pass on to future generations by being “communicatively useful” and easy for new learners to learn, so do programming languages, which is why most of the 2,300 programming languages have gone extinct (Sedivy, 2020, 55-56). As a result, binary (machine’s language) evolved to assembly languages with assemblers and then onto higher level languages with compilers and linkers, which mimic human languages and with which we are more familiar with today. Today, there are about 150 different programming languages (Coleman). And, just as the evolution of language in terms of writing found its publisher in the printing press, the evolution of programming languages found its publisher in the internet.

5. The Internet

As mentioned in the section on transitions, there appears to exist a pendulum of “centralization” and “decentralization” between cycles, yet there also appears to be a pendulum of defense of “personal/ individual sovereignty” and of “national sovereignty.” In the evolution of writing and the printing press, there was an emphasis on its use for self-sovereignty. However, in the evolution of programming languages and the internet, there is an emphasis on its use for defense of national sovereignty.

In response to the USSR launching the Sputnik satellite in 1957, in 1958, President Dwight D. Eisenhower formed the Advanced Research Projects Agency (ARPA) to develop the most secure communications technology, and in 1969 the ARPA network or ARPANET was born (Science Museum, 2018). In its origins, ARPANET “include over 30 institutions, encompassing government offices and businesses as well as universities, and connecting locations including Hawaii, Norway and the UK” and its primary use case was for researchers to communicate via email (Science Museum, 2018). However, just as linguistic evolution has required human and programming languages to be communicatively useful and learnable, a problem arose in that other networks were developed for computers who did not have Department of Defense contracts and they could not communicate with ARPANET or each other. So, with further similarities to writing developing through imprinting on the outside of a clay envelope, in 1974, “Bob Kahn and Vint Cerf, proposed a new method that involved sending data packets in a digital envelope or ‘datagram,’ or “the transmission-control protocol (TCP), [which]

allowed computers to speak the same [universal] language” and talk to each other (Science Museum, 2018). At this evolution, TCP/IP, or Transfer Control Protocol/Internet Protocol was born, and on January 1, 1983 when “ARPANET and the Defense Data Network officially changed to the TCP/IP standard,” the interconnected network of networks or the “internet” was born (University System of Georgia; Science Museum, 2018).

What the printing press did for culture and the written word of human language, the internet did for culture and the computer code of programming languages. As the printing amplified the work of the cultural revolutions that the number zero sparked, challenging monopolies on knowledge, disseminating and democratizing knowledge by lowering the literal and physical costs, making it more scalable, the internet, operating in cyberspace, allows these realities on a larger scale. Tangibly, the author considers the ease of thinking through, writing, and editing an essay on a computer, rather than by hand with a pen and paper. Further, while the printing press predominantly offered a static one-way communication protocol, the internet serves as a dynamic two-way communication protocol. While in human exchange through barter there was no time delay, with the printing press there was a reduced but still present time delay. However, with the internet, the time delay is virtually back to nonexistent. In its origins, the internet represented a participatory network for knowledge exchange and creation, furthering linguistics, culture, and technological evolution. Yet, in its current form, the internet often falls short, but decentralized and open-source protocols such as Nostr (Notes and Other Stuff Transmitted Through Relays) will help it make good on its promise.

6. Bitcoin

Encountering the double coincidence of wants problem led to the evolution of monetary and non-monetary languages, language protocols. Critically, the word language is used here because humans and human exchange lie at the center of this problem and language not communication, as established, is uniquely human. Writing, a form of a non-monetary language protocol, was a result of a means to solve and an inability to solve the double coincidence of wants. Or rather, it was a way to abstract informational data concerning goods or debts without regard to the location of the good, that was understood across many languages, and that was knowable to more than the initial knower (Schmandt-Besserat, 2014; Bickel et al 221). Further, writing through printing the token in clay allowed any sense of plurality to be abstracted. This

meant there no longer needed to be an underlying physical object for the representation, highlighting the shift to a conceptual linguistic system (Schmandt-Besserat, 2014).

Similarly, money and currency, a monetary language protocol, was also an abstraction of data (such as your time and energy) and a result of a means and an inability to solve the double coincidence of wants. Hence, why a good money should be salable across time, space, and scales and fulfill its three main functions as a store of value, a unit of account, and a medium of exchange while being sufficiently verifiable, fungible, portable, durable, divisible, agreeable/acceptable, and scarce (Yakes, 2021). Bickel et al. present an interesting hypothesis that “linguistic evolution emerged when societies of mutual trust and mating grew beyond the point where one could know all members individually” (Bickel et al., 2024, 218). Human exchange through barter can only go so far and money steps in as a solution.

However, while language as a paradigm has been allowed to evolve over time as we can see from writing (in its layers of abstractions) to programming languages, money has not been allowed to properly evolve. Writing evolved because economic incentives of second and third parties were aligned to represent semantic meaning through abstraction. Money has not been allowed to productively and ethically evolve because economic incentives, particularly through third parties, were aligned to exploit economic meaning through abstraction. This inverse relationship further highlights how both monetary and non-monetary languages are un-aligned with theories such as the transmission model of communication, which ignore how successful communication is more than just information transfer. For human language, it disregards the importance of context and use for developing and preserving semantic meaning and structure (Christiansen & Chater, 2022; Nölle et al., 2018; Arnon et al., 2024). For monetary language, it disregards the importance of context, use, and scarcity, for developing and preserving economic meaning (value). In the evolution of non-monetary language, the shift from physical to digital rails promotes value, such as knowledge, by reducing the cost of communication semantic meaning. In the evolution of monetary language, if scarcity of the supply is not required, the shift from physical to digital rails dilutes value by reducing the cost of creating economic meaning. With digital bookkeeping and fractional reserve banking, money can be digitally printed, made physical in its effects on the individual.

Further, while Shcherbakova et al. disagrees, Raviv et al. and Reali et al. convincingly show that community size, network density, and connectivity do appear to influence language

evolution and systematicity with large communities developing structurally simple languages and small communities developing structurally complex languages (Shcherbakova et al., 2023; Raviv et al., 2019; Reali et al., 2018). However, simplicity in structure appears to give way to abundance in non-structural properties like vocabulary of content words (Reali et al., 2018, 1). Reasoning for these phenomena include that as the world becomes more connected, it's easier for simple structures to diffuse or be learned, words alone do not require many exposures to be learned, and easy linguistic evolutions beget more innovators which begets more innovations (Reali et al, 2018, 1-2,4).

As such, today around 7,000 languages are spoken on Earth, but 44% of all the information in the world is produced in English, followed by 7.6% in German (BBC, Lobachev, 2008). Further, most monetary information is denominated in dollars, not necessarily because it is structurally simple, easy to use, or has won out in the survival of the fittest, but rather with help from agreements formed at Jekyll Island, Bretton Woods, and regarding the Petro Dollar and the exploitation of billions around the world. Also, as structural simplicity can give rise to an increase in content words, similarly, money grows in value the more people who speak it, use it, exchange it; value accrues through transmission. However, whereas in non-monetary language, grammatically, sounds can simplify e.g. “going to” → “gonna,” emptying words of meaning as you may no longer be “going” anywhere yet “soundness” and order prevails, in a monetary language, structurally, altering the “soundness” e.g. increasing the money supply, diluting the meaning, breaks it and chaos ensues (Christiansen & Chater, 2022, 44).

Thankfully, in 2008, a communications protocol arose as a solution to the exploitation in money by programming digital scarcity and removing third party involvement (Nakamoto, 2008). Since 2009, money has evolved because economic incentives, particularly through third parties, are aligned to preserve meaning through abstraction. And, like non-monetary language, individual human beings are at its core in creation, distribution, and preservation. As the internet was a protocol of semantic information packet exchange across a distributed network, scaling human linguistic and intellectual exchange, bitcoin represents a protocol of monetary information packet exchange across a decentralized and distributed network, scaling human value exchange. Bitcoin is the interconnected network of peers for money. As computers and programming languages are based in binary, we see this ergodic involvement of the number zero in bitcoin. As the printing press led to a revolution separating church and state, bitcoin might just

also lead to a separation of money and state. And, while, a language structured by a universal grammar on a single substrate of abstract math and science foundations void of culture is implausible for non-monetary languages, a monetary language built on a genotypic substrate of code backed by math and physics to preserve scarcity and a phenotypic substrate of community is the answer of how money must best evolve. Preserving value across time and space, bitcoin amplifies freedom of distribution not just for information but for value and collaboration for all eight billion people. Bitcoin is a language for innovators and begets innovation, catalyzing a new age of evolution and collaboration across linguistic, technological and cultural dimensions.

Conclusion

“At some level, the same socially oriented learnings that drive humans to “invent” thinks like laws and money also make it possible for them to communicate through language. Language, law, and currency all require people to buy into an artificial system that exists only because everyone agrees to abide by it...Our words are quite literally figments of human imagination, and they have meaning only because we all agree to use the same word for the same thing”
(Sedivy, 2020, 22).

Language, humanity’s first and most enduring interface, is ever evolving and has driven every major cultural and technological revolution. Innovations like the number zero, writing, the printing press, code, the internet, and bitcoin create feedback loops that enhance collaboration and preserve knowledge. However, this interface is bi- and tri-directional; these advancements are deeply interconnected. Zero as an evolution in the language of math led to technical and cultural evolutions. Stemming from cultural evolution, writing as a linguistic evolution preserving information furthered evolution across all paradigms. The printing press, a technological evolution amplifying writing, had sizable impacts on all paradigms as well. Together, zero, writing and the printing press bridged linguistic evolution into the digital realm through programming languages. And the internet, amongst much else, was home to the Cypherpunks Mailing List, birthplace of the linguistic, technological, and cultural evolution that will drive our society forward. Each paradigm feeds into each other and the Venn diagrams that could be drawn from their interplay is infinite (although not yet mathematically verified). Trade, transactions, and human exchange have been at the basis of each of these evolutions; all transformational innovations have been spread on a peer-to-peer (P2P) basis. Further, these

evolutions are learnable, useful, and survive, because they embrace decentralization, a permissionless nature, and an open-source ethos. Notably, evolution across the paradigms goes through cycles of centralization and decentralization (of abstraction) and of defense of individual or national sovereignty. Before writing, language was centralized in its holder and receiver. After writing, language decentralized, yet it centralized again by institutions such as the Church or ARPANET. However, with increased distribution through technological innovation such as the printing press and TCP/IP, language continued evolving to decentralization. Similarly, money, which has not been allowed to naturally evolve, has been a centralized abstraction, which is now trending towards a decentralized abstraction made present in each of its holders (Blanchard & Hayek, 1984).

“The precursors of money, along with language, enabled early modern humans to solve problems of cooperation that other animals cannot - including problems of reciprocal altruism, kin altruism, and the mitigation of aggression. These precursors shared with non-fiat currencies very specific characteristics - they were not merely symbolic or decorative objects” (Szabo via Alden, Broken Money).

What makes a language meaningful and useful is the community that speaks it and the tech that scales it. Today, only 4.17% of the world’s population can natively speak the world’s monetary language. Further, only 13% of the world’s population is born into the dollar, euro, yen, pound, Australian dollar, Canadian dollar, or franc system while “the other 87% are born into autocracy or considerably less trustworthy currencies[,] 4.3 billion people live under authoritarianism, and 1.2 billion people live under double- or triple-digit inflation” (Gladstein, 2021). The money we have today is broken; it’s not linguistically or communicatively useful, unable to hold or preserve value across time and space and unable to be spoken by all of humanity. “Peer-to-peer” means any node of any size can speak to any node of any size, anywhere. Imagine the technological and cultural evolution we can unlock through an open monetary language, facilitating greater human connection. Following feedback loops, imagine what these unlocks might imply for the future of language evolution. The importance of bitcoin as a peer-to-peer electronic cash system, the 21 million bitcoin as tools for trade, should not be underscored and will have a transformational effect on the 21st century.

Despite the interplay among these three paradigms of evolution, linguistic evolution remains at the heart of all change. Language is uniquely human and human exchange is at the

root of all major cultural and technological progress. Community is society's greatest technology and language is how we build it, engage it and preserve it. Linguistic evolution has driven evolution in a "sly roundabout way" (F.A. Hayek). When thinking about the future, the world is dynamic, a reaction to human action. We can't plan out the future precisely. All we can do is when approached with a decision, make a decision aligned with the values we want to guide our lives by. A fear-based response to future uncertainty in evolution is to seek control. Our greatest tool was "a collection of accidents," so we should take that as a lesson as the power of decentralized protocols for navigating uncertainty. The answer to the future is free-market evolution and an embrace of decentralized, permissionless, and open-source protocols, the most resounding of which is humanity.

Every generation has a tendency to fear the unknown or unfamiliar. But, upon reflection, history frequently rhymes. Humans, just like us, navigated the past by continuing to speak and communicate and that should be our strategy for the future. The only thing we should fear is an inability for human exchange; a breakdown of human transactions. Just as humans are chunk-based learners who improve with practice at making it through the "bottleneck" to acquire language and who rely on their "Communication Iceberg" to facilitate "good-enough" understanding in conversation, the same can be said with how we move forward in our interaction with our reality. We continue to be "chunk-based learners" who take each day at a time and who rely on past experiences and each other to facilitate understanding. In a world attuned to the digital, language emphasizes the power of the physical in humanity to achieve, succeed, and evolve.

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