The Nexus of Storytelling and Collective Learning: A Synergistic Spark for Human Emergence

John Hasse
Rowan University

Correspondence | **John Hasse** hasse@rowan.edu
Citation | Hasse, J. (2023) The Nexus of Storytelling and Collective Learning: A Synergistic Spark for Human Emergence. *Journal of Big History*, VI(3); 60–83.
DOI | https://doi.org/10.22339/jbh.v6i3.6306

Keywords: Big History, storytelling, collective learning, language, emergence

Abstract: This paper explores the implications of storytelling as an essential complimentary concept to collective learning for labeling human emergence within the Big History thresholds framework. It proposes that the distinctively human cognitive capability for communicating explanatory descriptive narration (i.e., storytelling) was a foundational adaptive behavior and central driving force that launched humans into a unique evolutionary pathway as collective learners whose increasing knowledge has transformed the world. Storytelling provides a theorem for why human language skills and brain capacity increased so dramatically since our common ancestor with chimpanzees, and how our storytelling brain models our world through narratives that undergird human belief systems and facilitate complex social coordination. The paper outlines the symbiotic role that storytelling played in turning the cultural "ratchet" of collective learning throughout prehistoric times and its corresponding influence on prehistorical milestones. It goes on to explore the benefits of teaching storytelling as a complement to Big History threshold (6) collective learning and concludes with a look at the vulnerability of the human storytelling brain regarding its ability to unite or divide people through the power of narratives, whether they are factual or fictional. The paper invites the Big History community to consider embracing the emerging transdiscipline of storytelling within the Big History tent as synergistic complement to collective learning, that pulls together many Big History threads and which can help improve the effectiveness of telling Big History as a common human origin story for navigating the precarious prospects of the Anthropocene.

Introduction

The emergence of humans in the evolutionary story of the universe is a prominent topic within the canon of Big History. But what makes homo sapiens so substantially different from other large brainy animals that it warrants designation as one of only 8 threshold events in the scale of the evolution of the universe? When can we say that humans became quintessentially "human" and how did that transformation happen in an astonishingly brief few million years since diverging from a common ancestor with chimpanzees? What can explain how we gained the superpowers of human culture to spread around the world into wildly different environments, created a vast technologically advanced global civilizations and come to dominate the entire biosphere? Can a better understanding of what makes us uniquely human help us to negotiate the turbulent predicament we have created at this moment in history through the overshooting of our global planetary boundaries?

While generations of brilliant researchers and writers have been exploring these questions of human significance from a multitude of disciplinary perspectives employing continually developing advances the sciences, the maturing transdiscipline of Big History with its all-encompassing framework of time and space also has much to contribute to the discourse. Central to Big History's treatment of human emergence is the theory of "collective learning." Collective learning is the uniquely human ability to accumulate, increase and pass on knowledge between current and future generations thus giving rise to our unprecedented population growth trajectory, prodigious cultural creativity, technological advancement, and subsequent massive impact on the ecological functioning of the planet. Big History sectionalizes the evolution of the universe into eight thresholds of increasing complexity. Human emergence is the sixth threshold and is often branded with the label collective learning. While this paper engages the framework of Big History thresholds and continues the convention of human emergence as threshold (6) to maintain continuity, it recognizes the inherent limitations and subjectivity of using a numbering system to label such evolutionary thresholds (Spier, 2022). Regardless of the label, the human species' experiment with collective learning and the modern world that it has produced is arguably consequential in the story

of the evolution of the universe.

Big History joins a collection of multiple works over the past half century that have reflected on the place of humanity within the larger epic narrative of the evolution of the universe. Carl Sagan (1980) presented the story of cosmic evolution as a captivating narrative portraying the universe's journey from the Big Bang to the emergence of life and human consciousness. Jantsch (1980) presented self-organization as a fundamental principle that underlies the emergence and development of complex systems within the universe. He emphasized the interconnectedness and interdependence of systems at different levels, from subatomic particles to galaxies, and from individual organisms to social structures. Jantsch proposed that humans possess a unique capacity for conscious self-reflection and intentional action, enabling them to participate actively in the co-evolution of their societies and shape their own future. In contrast to thresholds of increasing complexity, Jantsch organizes the line of thought into four periods: Cosmos Evolution (Astronomy & Physics): Life Evolution (Biology & Earth sciences): Human Evolution (Anthropology): and Civilization (regular history). Preston Cloud's "Cosmos, Earth and man" (Cloud, 1980), explores the intricate relationship between humanity and the universe, guiding readers through a profound reflection on humanity's place in the vastness of space to contemplate humanity's role in the grand scheme of the cosmos. Swimme and Berry's "The Universe Story" (1992) narrates the history of the universe from its origins, emphasizing the interconnectedness of all phenomena and the emergence of complexity, consciousness, and ecological awareness. A central question explored across these works and many others, notwithstanding, is how to place the significance of humanity within the universe.

While my academic preparation as a land use geographer did not include training in human evolution, paleolinguistics or the cognitive development of the human brain, the deeply transdisciplinary field of Big History grants license to practitioners to step into areas outside of their expertise in order to explore broader interdisciplinary connections between often disparate fields. What my geography disciplinary preparation has given me is big picture thinking and skills in identifying the patterns that connect seemingly independent component parts into complex functional systems. I also bring to this paper more than 15 years' worth of experience teaching the fundamentals of Big History within an introductory undergraduate geography class and the spark of ideas presented herein emerged out teaching the evolution of humans within the Big History context. When the call for a special edition of the Journal of Big History with the theme of "Big History-Reexamining Fundamentals" came, I felt compelled to share insights gained through teaching Big History and especially regarding the essence and meaning of human emergence developing ideas that have connected exceedingly well with students on the significance of being a homo sapien.

Threshold (6): Collective Learning-Human Emergence

The course through which many of the insights discussed in this paper have arisen is titled *Earth, People & the Environment* (EPE). A simple formula describing the class is EPE = Big History + Maps (i.e., physical/human geography) + Anthropocene. The purpose of this general education course is to orient students in their time and place within the changing world they will be entering. I developed and began teaching EPE in 2006 by offering two sections with a combined total of 52 students. During this past academic year (2022-2023) Rowan University offered 35 sections of EPE taught by thirteen different faculty for a total of 1,256 students enrolled for the year. The full story of the success of EPE for teaching Big History will need to be saved for a different article that will focus on Big History pedagogy through a geographic lens. Notwithstanding, as EPE has evolved at Rowan over the past decade it has been a living laboratory for how students assimilate a course that places their own lives within the narrative of the larger arc of life on our remarkable planet during a time of critical urgency. What has been especially rewarding with this class is that students have contributed to the evolution of discourse over the years as they have helped to expand ideas regarding the process of human emergence and significance of homo sapiens in the grand narrative of the universe.

When the course gets to human emergence (threshold (6) in Christian's framework) it invariably generates widespread and enthusiastic engagement among students. We explore the questions of what distinguishes "us" from other species. We explore the physical changes of upright walking, opposable thumbs, brain enlargement, tool usage and fire. We examine the branching of different hominine species, brain enlargement, climate change throughout the Pleistocene and the waves of human migration out of the African motherland. We dive into language, settlements,

and artifacts of artistic and ritualistic expression. We organize these ideas and lay out the theory of *collective learning* as a key concept in Big History (Baker, 2015).

Collective learning is the Big History theory originated by David Christian that provides an explanatory mechanism for cultural evolution that brings human history into a compatible framework with the increasing cosmological complexity of the emergent universe. Collective learning is the process of knowledge being shared by one member of a community with other community members and/or with succeeding generations so that it can build and accumulate more knowledge than any single individual could do on their own within a single lifetime. Christian describes collective learning as "our unique capacity for sharing and accumulating information" (2018, p.173). It is an "information ratchet" that "stores information in many minds over many generations, so that information can outlive the individual who created it" (Christian, 2015, p.30). With collective learning, "new information accumulates at the level of the community and even the species" (Christian, 2015, p.30). "The ecological knowledge contributed to that pool by each individual can survive long after his or her death. So, knowledge and skills can accumulate non-genetically from generation to generation, and each individual has access to the stored knowledge of many previous generations" (Christian, 2011, p.241). David Baker has written on collective learning as a foundational unifying theme within Big History in the context of the rise of complexity in the universe:

> "Collective learning… has allowed humans to exploit our ecological niches with increasing efficiency and allowed us to largely harness the energy flows of the planet and the Sun. Through foraging, agriculture, and heavy industry collective learning has raised the carrying capacity of the population, allowing for more potential innovators, who in turn raised the carrying capacity, thus creating even more innovation. Gradually, over 250,000 years of humanity, the population has risen and we have generated increasingly complex societies and have developed the capacity to harness an enormous amount of energy. In terms of the wider rise of complexity and in processes of Universal Darwinism, collective learning is the summit of the process (Baker, 2015, p.82).

David Christian distinguishes collective learning as analogous to a Darwinian adaptive process within human culture.

> "Humans as individuals are not that much cleverer than chimps or Neanderthals; but as a species we are vastly more creative because our knowledge is shared within and between generations. All in all, collective learning is such a powerful adaptive mechanism that one might argue it plays a role in human history analogous to that of natural selection in the histories of other organisms" (Christian, 2011, p.243).

The theory of collective learning provides a compelling mechanism for the increase in cumulative knowledge that a given social group possesses, how that knowledge accumulates and increases in pace over time, and how the technological application of that increasing knowledge resulted in homo sapiens continually finding new means of exploiting energy and other resources.

A Big Blank Spot on the Collective Learning Map

As sagacious as the collective learning thesis is, one can nevertheless be left with a sense that the idea on its own is limited as a standalone label for capturing the uniquely essential nature of humanity. While collective learning does provide a compelling framework, the theory only goes so far in capturing the full essence of the human enterprise. There are indispensable aspects human existence that are not well captured by the term 'collective learning'. Indeed, there are significant gaps in collective learning theory's ability to provide a satisfying explanatory mechanism for many essential human behaviors. Whereas the historical outcomes of collective learning have been a major focus of the Big History scholarly work to date and are thus most fully developed, an explanation for how collective learning came to be, how it functions, how it collects, processes, stores and disperses knowledge learned and how it has changed over time in lockstep with the evolving human brain, has been less explored. Christian does make reference to the antecedents to collective learning as being the result of "evolution of an exceptionally powerful form of language that allows us to exchange ideas and insights with such precision and in such volume that they can accumulate in collective memory "(Christian, 2018, p. 15). Additionally, Christian, Brown, and Benjamin describe how human

symbolic language allowed "the ability to share in great detail and precision what each individual learns" (Christian et al., 2014, p.89). But there has been far less exploration in Big History discourse as to what drove the evolution of the human brain to be so highly developed, manipulative, perceptive and at such a high level of neurological capacity that symbolic language and collective learning could begin to take place? As Baker acknowledges, there is a "big blank spot on the map …[regarding]... what ability, origin, and selection pressure caused collective learning" (Baker, 2015b, p.304).

A big blank spot on the map is too enticing for a geographer to ignore and thus we dig into this blank spot by exploring what systems undergird collective learning. For collective learning to take place it must have an underlying system for collecting information, conceptualizing information into useful knowledge, distilling the information into experience and extracting the wisdom of the knowledge. There must be a system for information storage and retrieval, transfer between information keepers and a system of knowledge dissemination to the community. And for a culture to be meaningfully employing collective learning there must be a mechanism for cultural motivation for agency and action. Thus far there has been little written about the underlying mechanisms through which collective learning takes place and how it would have evolved over time.

My EPE students have picked up on the big blank spot regarding the limitations of the concept of collective learning. As powerful as collective learning theory is, students have nonetheless questioned whether collective learning on its own is adequate in providing a satisfying explanation for what makes humans uniquely human beyond their role as accumulators of knowledge. To some students, the terminology of collective learning was characterized as overly academic and insufficient for conveying complex behaviors, cultural expressions and philosophical and spiritual insights through which humans live their lives, interact with one another, and interface with the other species in which we share the biosphere. Students have pointed out that not only do humans learn collectively, but they also worship collectively, they celebrate collectively, they play collectively, they perform collectively, they laugh together, and they share emotional responses with one another. Humans also work collectively in society, they fight wars collectively, and they express art to other members of one's community. These are also defining characteristics of what distinguishes humans from other species that are not adequately captured by the Big History label as humans as the collective learning species.

Perhaps most significantly, collective learning as the label for human emergence does not convey the ability of humans to make meaning. As one EPE student postulated, collective learning theory on its own might be sufficient to describe the evolution of the purely logical (and science fiction) brains of Vulcans from Star Trek but humans have a lot more than rational logic driving our behavior that can be explained by accumulated knowledge alone. Furthermore, the explanation for how collective learning occurs is attributed to "joining individual learning to a sufficiently powerful system of communication" (Christian, 2015, p.71). Clearly collective learning can only be possible with symbolic spoken language of homo sapiens but there has been little development in the Big History literature for what takes place with human language that results in collective learning taking place compared with other language systems of other species that don't collectively learn. How is the knowledge that is collectively learned, shared, transmitted, stored, recalled, managed, assimilated, and leveraged into behaviors that sustain life and that can be passed down to benefit subsequent generations?

In exploring this discourse, I and some Rowan colleagues that also teach EPE began contemplating other themes that could complement collective learning to explain what uniquely drives many human behaviors, what motivates our actions, and how those actions have shaped the specific events of history. Bearing in mind that in an exceptionally short time span of only several million years of evolution, homo sapiens have gone through a remarkable biological development of cognitive complexification that has increased the human brain volume threefold resulting in human mind becoming vastly different in what it does and how it works and how humans behave than our closest evolutionary cousins, the chimpanzee, and bonobos. What drove the human brain to expand so rapidly, to develop symbolic language, to increase cognitive perception and to develop conscious self-reflection and awareness? To begin to fill in Baker's big blank spot in collective learning theory, we might explore the divergence of hominins from chimpanzees.

What distinguishes human language from that of other primates?

When discussing the differences between humans and chimpanzees, students will invariably say that 'chimps

cannot talk like humans.' I respond, "do chimps have language"? If one takes a broad definition of language as a 'a systematic means of communicating ideas or feelings using conventionalized signs, sounds, gestures, or marks having understood meanings' (Miriam-Webster, 2023), then yes, other primates including chimps have been shown to have fairly sophisticated language. Vervet monkeys were shown to have three distinct calls for warning from danger from pythons, lions, and eagles. When recordings of the calls were replayed, members of the group responded in an appropriate way for the predator indicated in the call (Seyfarth et al., 1980). Noted primatologist Jane Goodall documented the nuanced communications of chimpanzees in the wild over five decades of her research of chimpanzees in the wild (1986, 2010). She revealed that chimps use gestures, pant-hooting grunts, and other vocalizations to communicate needs, wants, emotions, warnings, etc. demonstrating many communicative behaviors analogous with human communication. Goodall's work has pioneered chimp behavioral research in the field and inspired generations of other researchers who are developing increasing knowledge about chimp communication and behavior revealing complex language capabilities including communicative interactions and comprehension of symbol-referent relationships (Savage-RUmbaugh et al., 1986). Other researchers have explored the extensiveness of great ape gestural communication (Moore, 2015;, Townsend et al., 2017). Hobaiter and Byrne (2011, 2014), have been developing a dictionary of chimp vocabulary observing over 60 gestural indications of distinct units of communication. The dictionary demonstrated that chimps have the cognitive ability to comprehend/model systematic symbolic meanings to those communication units. Girard-Buttoz et al. (2022) documented 390 unique vocal sequences produced by chimpanzees in not only single vocal units but also in two-unit sequences (bigrams), which in turn were embedded into three-unit sequences (trigrams). Schel et al. (2013) observed that chimps, when presented with the threat of a python (a rubber model in the experiment), vocally communicated alarm calls intentionality directing their communication to arriving community members while visually monitoring of the arriving member's reaction and only stopping when the members were safe thus demonstrating goal-directed behavior. Leroux et. al. (2023) performed a similarly designed python study finding that the specific sequential combination of calls resulted in different reactions than the calls made individually or in a different sequence demonstrating that the cognitive building-blocks facilitating syntax may have been present in our last common ancestor with chimpanzees.

The Leroux study probably serves as a good example of the upper level of language complexity for combining multiple "words" together for chimp communication of ideas in the wild. A chimp can combine three words to communicate, in essence, the equivalent of "danger - python - caution". One can see the evolutionary benefit for chimps to be able to communicate this information to one another. But those three ideas clustered as a combined unit of information seem to be the limit of conceptual communication complexity that a chimp can cognitively model. Chimps do not have a need to string more than a few words together to be able to survive just fine in their social structure within their jungle habitats. Chimps arguably have functional language that they use for communicating many important purposes such as warning, grooming, soliciting sex, expressing anger, eating, etc. with no more than a trigram combination level of communication. However, with a trigram maximum, chimpanzee language is not able to explain more complex ideas or narrate actions not so much because they don't have the linguistic capabilities but because they don't have the cognitive equipment to model those ideas or make conscious sense of a sequence of more than a few words strung together. Chimp brains do not have the neural circuitry to think and visualize in explanatory narratives, remember explanatory narratives, understand someone else's explanatory narratives, or take action based on the understanding of explanatory narratives. Simply put, chimpanzees cannot tell stories and cannot understand stories told to them and thus cannot make larger symbolic meaning of explanations and narrations or have agency based on story.

In contrast, humans can string many hundreds of communication units together to create a much more sophisticated cognitive model of the world around them and can conceptualize the sequence of events experienced within that world into meaningful ideas. The brainpower for human communication necessitates not only the language skills for making and interpreting the sounds and gestures of speech, but more significantly, it requires the cognitive modeling of the ideas behind the communicated information. Homo sapien brains can do all those things because we've evolved the adaptive behavior of *storytelling*. We've developed the cognitive circuitry to model our complex world into narratives in which we visualize and

explain what happened, transfer those cognitive models through a sequence of multiple communication units that convey those sequence of events, decode those sounds and gestures within the listener back into visual cognitive models of what happened and ultimately derive deeper meanings to the narrative sequence. As far as we know, no other species models the world through storytelling. Homo sapiens, as Jonathan Gottshall (2012) has posited, can be thought of as the *storytelling animal*. While many species could arguably be considered sapient at some level, homo sapiens might be more appropriately labeled *homo historicus*, the storytelling human.

For the rest of this paper, I use the term *storytelling* as shorthand not just for the spoken account of a narrative but for the entire package of human adaptations related to our unique narrative explanatory cognitive modeling system through which we experience the world. We are different from other primates because we think in narrative explanatory models, we share those narrative thoughts through our sophisticated largely oral language communication system, we decode the explanatory narrative model in the brain of the listener which visualizes the narration in their imagination and derives the emergent meanings encoded in the narrative.

Of course, human language has many more functions than solely facilitating storytelling. Like our primate cousins, human language is used for warning, grooming, soliciting sex, expressing anger, communicating about food and so on. Nevertheless, storytelling is arguably the main behavior that distinguishes us from other species. One can see the analogy of the evolution of the feather by Mesozoic dinosaurs which employed feathers to perform multiple functions such as to insulate, shed water and display mating information etc. But there is a strong case to be made that the most significant evolutionary application of the feather was to facilitate the adaptive behavior of self-powered flight. Paleontologists are discovering that many dinosaur species possessed feathers including velociraptors (Turner et al., 2007), but only archaeopteryx used feathers for a new adaptive behavior of self-powered flight launching a revolution in a successful adaptive behavior that has subsequently differentiated into 11,000 species of modern birds. Many animals have a form of language but only humans have evolved language into the novel behavior of storytelling which has been differentiating ever since into myriads of global cultures today. If storytelling is indeed an adaptive behavior, it would have had to emerge through an incremental process of Darwinian natural selection.

The Emergence of Storytelling: A Thought Experiment

A thought experiment can walk one through that transition from ancestral pre-human with a comparable trigram language capability of modern chimps to the storytelling hominid ancestor of modern humans. We begin our mental exercise at some point after the last common chimp human ancestors diverged into ancestral hominids and ancestral chimpanzees. What would be the outcome when one of our hominid ancestors began incrementally increasing the number of units of language communication strung together beyond three. Perhaps they were able to add a locational dimension to their communication so that "danger-python-caution" which we've established chimps essentially can communicate became "danger-python-***waterhole***-caution". No doubt many mammals have locational capabilities within their brains. Elephants can remember and return to watering holes that they have not been to in years (Moss, 2012). An elephant can lead others to the place it remembers but it can't abstractly communicate that place to another. So, adding an abstract symbolization of a specific location is a significant step in cognitive modeling of language development. One needs to first abstract the idea of a specific location, symbolize their location in the environment and then symbolically communicate that modeled geographic location to the listener in a way that they can decode the location. No small task for an evolving hominin brain.

The single addition of an abstraction of locational information to the sequence of communication units could have a beneficial outcome for the individual receiving the information, as well as their family or potentially the whole community. For example, it would be beneficial for the band if that sequence of communication "danger - python - waterhole - caution" was shared with members of the community that were not at the scene so that more community members could avoid the waterhole or it could be beneficial if a member heard it from someone other than the original observer thus increasing the number of community members that benefit by this potentially life-saving information. This is only one "word" more complex than modern chimp language but already hinting at the beginnings of proto-collective learning. Information gained by one member could benefit many other members of the community without them directly experiencing the event. But perhaps more significant than the language

complexification of stringing 4 words together is the increasingly complex cognitive modeling necessary for that extra added word to be meaningful. The development of cognitive neural networks representing an abstraction of an event of significance occurring in a specific location is a big leap in complexity beyond chimp cognition and likely would have taken extensive generations of natural selection and the development of unique cognitive modules for abstracting locational comprehension in symbolic communication.

Adding the capability for a 5th word to the string of communicated information continues the complexification. Let's say the fifth word personally identifies an individual community member in the band with a unique vocal call. Now we need to cognitively model the idea of individual identity through some kind of unique symbolic representation. The idea of a personal identifying name would need to be added to the proto-human language tool kit. Let's say Fred was the one who observed the python and communicated that to others as it was happening. If a first-person listener to Fred later passed the information to another who did not observe it directly using Fred's name to identify the individual engaged in the action the communication would add a 5th word to become "Fred-danger-python-waterhole-caution." Now we need to have a way of changing the meaning to past tense to signify 'was cautious' (or was not cautious as we shall see) initiating the need for developing grammatical tenses in language. Somewhere in that ability to add a few additional words of linguistic complexity proto humans would begin to have a cognitive abstraction of the experience of the world that begins to be uniquely human. At some point human brains go from living purely in the moment like our chimpanzee cousins (e.g., communicating the immediate wants and warnings driven primarily by instinct) to a brain that begins abstracting the moment into a narrative model that can first be created in one individual's mind, then be shared with another so they can comprehend that narrative explanation, which can then be transferred to the minds of a third or fourth or 20th person without direct observation. We are beginning to see the need for distinguishing between in-the-moment communication and communicating a conceptualization of past event as the ratchet of communication complexification is increased.

Adding the capacity for clustering six words of information communication takes an even larger leap toward distinguishing human language from chimp language. In our thought experiment we can imagine abstracting the occurrence of death. Certainly, the concept of death is experienced by chimpanzees in a manner accessible to the chimp cognitive capabilities. Jane Goodall observed on a number of occasions chimpanzees exhibiting behavior that suggested that chimpanzees were mourning the death of members of the community. In one instance a chimp child was observed tending her dying mother (Goodall, 2010). In another example a chimp community that had experienced the recent death of a chimp child was observed exhibiting striking behaviors of mourning (King, 2016). These examples demonstrate that chimps emotionally respond to death and instinctively avoid dying so death is arguably a salient concept to a chimp. But chimps don't have the language capability or the cognitive ability to abstract a narrative model of the idea of death. A chimp can likely feel the emotion of loss but can't say to another "my child died I'm sad." Imagine adding to our proto human language the idea of death to our string of communicated words.

"Danger-python-waterhole-caution-Fred-dead".

With the addition of this sixth word, something larger emerges than the simple meaning of the individual six words combined at face value. There is a deeper meaning conveyed that taps into the previous experiences and emotions of the listeners so that the narrative carries not only technical information for what happened through the six-word cluster but evokes a deeper significance of what happened. It's at this stage where the ability of the human brain to abstract events through narration and then derive meaning from that cluster of words that we cross fully into the realm of storytelling.

To illustrate the point that a story carries deeper meaning than the face value of the communicated words, we can invoke the urban legend of novelist Ernest Hemmingway writing the world's shortest story. Ernest Hemmingway was challenged by friends to compose a story with the fewest number of words possible. His response was to pen the following six-word story: "For sale, baby shoes, never worn." (Gottschall, 2021, p. 62) While the story itself has been questioned as to whether it can be authentically attributable to Hemingway, the six-word tale nevertheless captures the essence of what elevates a sequence of words to the level of becoming a story. A story typically carries something greater than the technical accounting of

something that takes place. The baby shoes story carries larger implications or meaning as to the significance of why the shoes are for sale implying death of an infant, the sorrow of parents who are selling the shoes and the lost potential to a life that will never be lived. The six words that make up the story say nothing about these deeper thoughts, but the listeners inject their own previous experiences and cognitive pathways to extract a larger meaning. This is a remarkable emergent property of human storytelling that becomes a narrative cognitive hologram for experiencing reality through narration. The human brain had to evolve the ability to conceptualize what's important about what happened and identify the so-what of what was communicated in the narration beyond the simple meanings of the individual words themselves. Like a star igniting from goldilocks conditions of gravity compressing hydrogen gas past the threshold of igniting thermonuclear fusion, the human brain crosses the threshold of chaining multiple words together until they animate explanatory narrative sequence of communication units into storylines that communicates a larger "so-what" of what takes place and the emotional meanings inferred.

A modern chimp cannot say "danger-python-waterhole-caution-Fred-dead". More importantly, a chimp brain cannot think "danger-python-waterhole-caution-Fred-dead" and understand the deeper significance of those sequenced words. But at one point after perhaps thousands of generations of incremental changes slowly increasing the number of words clustered into chains of ideas and the necessary cognitive architecture, one of our direct human ancestors began to express and comprehend explanatory narratives and the threshold into the new adaptive behavior of storytelling was crossed. In our thought experiment, storytelling became a central evolutionary driver explaining why our modern symbolic language developed with a capacity for vocabularies of thousands of words and our sophisticated recursive grammatical capabilities as necessary tools for communicating increasingly complex narrative models. We invented storytelling because narrative explanatory communication is an incredibly powerful behavior that models ideas and understandings of an infinitely complex world that, when symbiotically allied with collective learning, have come to transform the entire geo-biochemical functioning of the planet.

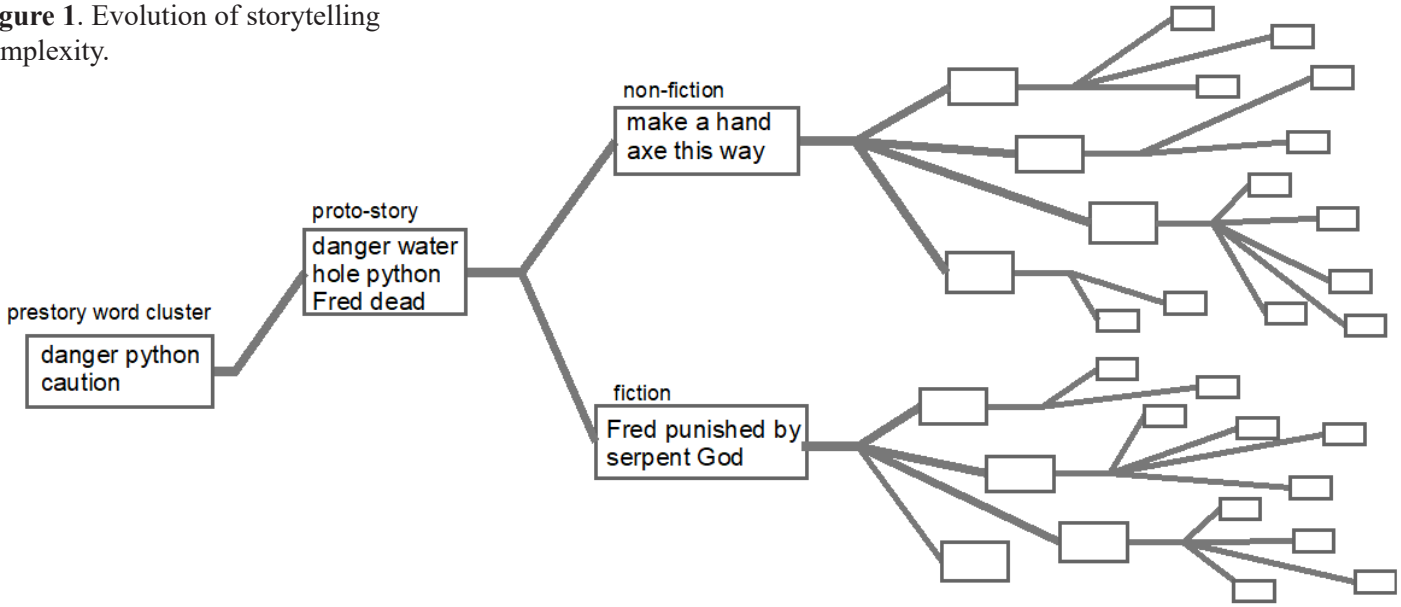
Building the Storytelling Mind

If storytelling is the adaptive niche of humans, then it would have evolved in a Darwinian fashion from the very simplest recounting of an event at the waterhole to an increasingly more sophisticated and nuanced capability for communicating more and more complex ideas through narrative. As our mind experiment continues, humans would have refined stories to be increasingly effective for avoiding danger and death or for finding or acquiring food. Telling stories would facilitate transferring learned behaviors such as the sequence in which to nap stone tools, fire making techniques and how to hunt more successfully. Each incremental variation in the usage of story for enhancing survival would potentially be passed on if it proved beneficial to the survival of the species. Perhaps natural selection of story would be amplified with sexual selection for more persuasive storytelling performances. Over the course of tens of thousands of generations, the evolution of storytelling would have resulted in stories differentiating into multiple categories or *story species* (figure 1) that served different functions within culture. Languages would have evolved in sophistication and vocabulary to better capture the nuances and timing of sequences within the narrative, who was doing the action, whether the action happened in the near past, long ago or what might happen in the future.

Along with the evolution of the vocalization capabilities of spoken speech that would be needed to convey the intricacies of story, the human brain would have had to evolve the cerebral architecture and neural pathways to perform all the functions necessary for increasingly sophisticated storytelling and story listening. The brain would have to develop the neural pathways to abstract symbolization of agents and actions in the world around them. The storytelling brain would need to develop the ability to visually imagine the narrative actions within the mind eye as well as the capacity to comprehend outcomes and consequences as cognitive models. A storytelling brain would require an extensive memory storage and retrieval system all with a highly plastic capacity for learning potentially not only thousands of words and the meanings behind them but the narrative themes and thematic meanings. The cerebral requirements for storytelling have resulted in the evolution of the human brain that has perhaps 86 billion neurons (Azevedo et al., 2009), three times the volume and number of neurons of our closest biological relative, the chimpanzee.

Comparing the relative simplicity of chimpanzee's non-storytelling cognitive modeling with that of the highly

Figure 1. Evolution of storytelling complexity.



Note: As an adaptive behavior, storytelling would have increased in complexity in a coevolutionary fashion with the increasing capacity of the brain to better model the world through a sequential cluster of words that abstracts meaningful understanding of what is communicated. Storytelling would have evolved from simple short descriptions of what recently happened to increasingly complex stories that could share more nuanced essential cultural knowledge. In this manner storytelling would have differentiated into different story categories and subcategories resulting in a spectrum of nonfictional and fictional story species.

complex cognitive sophistication of a modern storytelling human, one appreciates the massive amount of evolutionary change that occurred in only a few million years to result in a brain triple the capacity of our closest living evolutionary cousins. Figure 2 diagrams a schematic of the cognitive modeling of a modern chimp versus the cognitive modeling of a modern human brain. The Chimp brain (1) creates a cognitive model of reality from a combination of sources including (a) the direct sensory input of its five senses, (b) its personal memory of past experiences, (c) instinctual spontaneous drives, (d) social community input, and (e) the environment. This cognitive model is then provided to the module in which an individual experiences and interacts back with the world. I call this module a *personal conscious paradigm*. I have it labeled with a VR in the diagram since individuals experience the conscious modeling of reality provided by the brain as a sort of virtual reality that one may experience by putting on a VR headset. British writer Will Storr writes about the science behind storytelling describing the way the brain invokes the experience of consciousness:

> It feels as if we're looking out of our skulls, observing reality directly and without impediment. But this is not the case. The world we experience as 'out there' is actually a reconstruction of reality that is built inside our heads. It's an act of creation by the storytelling brain. This is how it works. You walk into a room. Your brain predicts what the scene should look and sound and feel like, then it generates a hallucination based on these predictions. It's this hallucination that you experience as the world around you (Storr, 2020, p. 21).

In the case of a chimp brain, that experience of its hallucination of reality is going to be based on its input of senses and its instincts. A chimp experiences life in the

moment within its environment and among its community with perhaps some experiential memories, input from other community members and certainly emotions. But a chimp's brain is unable to abstract a deeper meaning about the events going on. A chimp's personal conscious paradigm (VR) is its experience of reality at any moment and that present tense hallucination will be the basis that drives that chimp's individual actions (f). A chimp's cognitive model of reality is quite complex among all mammals, but it is far simpler compared with the brain of a human.

A human cognitive model of reality (labeled (2) in figure 2) is far more complex. While humans have essentially the same inputs of: (g) senses, (h) personal memory, (i) instinct (although atrophied), and (j) environment, humans have a variation of model inputs from their community which I have depicted as (k) close personal relations and (l) larger cultural community. A human's input from close relations and larger community enters the human brain mostly through language in the form of storylines. The stories can be as small as story fragments or as large as hours-long epics. The storytelling cognitive module (labeled (3) in figure 2) is the human storytelling processing center. It takes symbolic language input (i.e., sounds and gestures) and turns it into hallucinations of what the speaker is thinking through their language communication. The story module looks for characters that manifest actions, plots, and settings. It looks for patterns of narrative that fit its internal library of archetypal characters, processes, and narrative themes. The storytelling module draws on its vast memory of experiences and stories told over their lifetime to make sense and meaning out of the inputs and projects possible consequences into the outcomes. The storytelling brain draws on emotions and even ties into the motor circuitry of the body to create the vivid hallucination of a story as an experience that can be as viscerally real as the hallucination of reality that the brain creates from its sensory input alone.

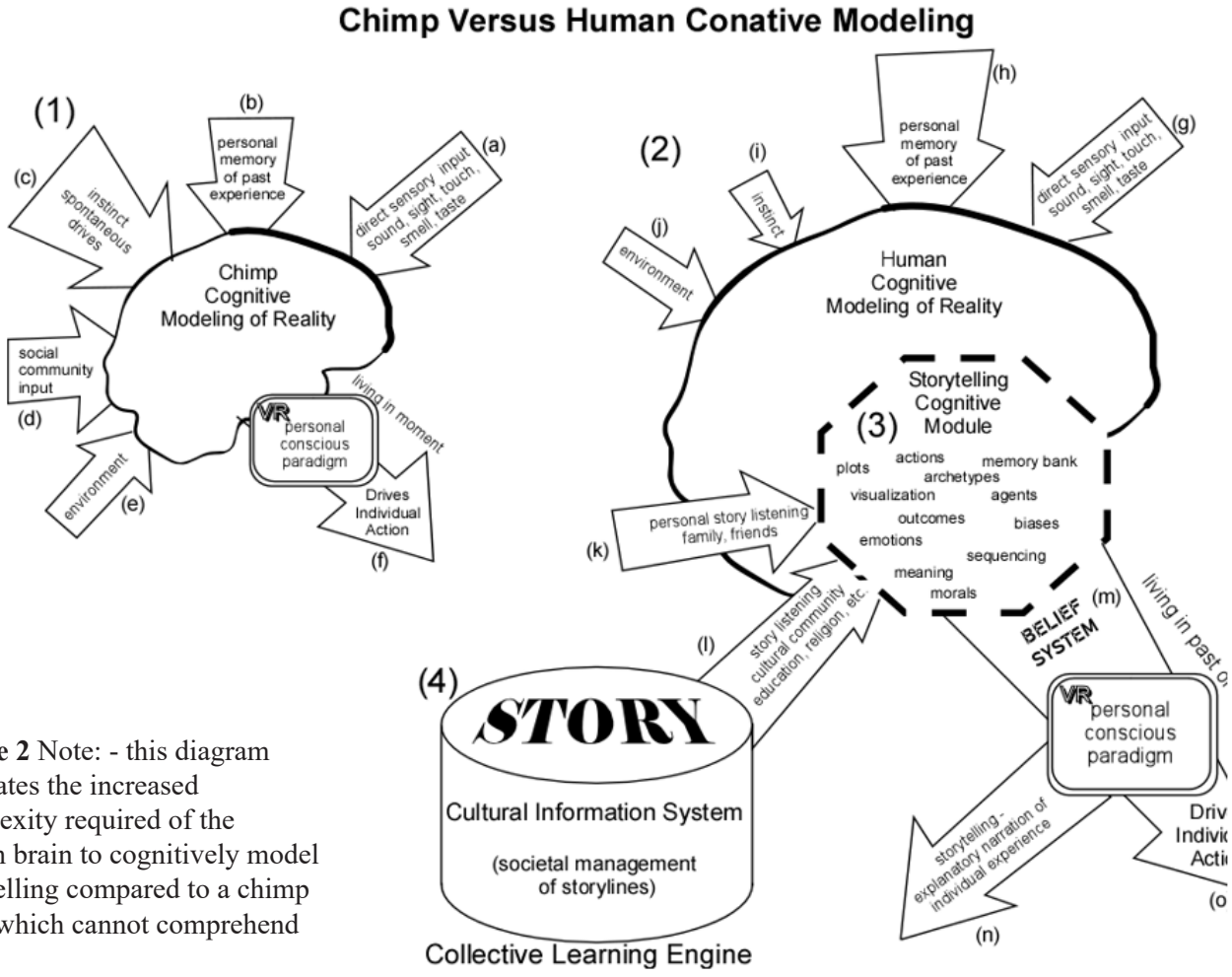


Figure 2 Note: - this diagram illustrates the increased complexity required of the human brain to cognitively model storytelling compared to a chimp brain which cannot comprehend story.

The human brain with its storytelling module takes all the story inputs, experiences, memories, and communications from other members, minimizes information and storylines that it deems least important or wrong and amplifies the storylines that it deems to be most valid through experience or provided by respective authorities and creates a living narrative belief system (m) or *meta-story* through which it experiences its personal conscious paradigm (VR). The personal conscious paradigm of a human (its hallucination of reality) is then available to send stories back to the community through their own storytelling faculties (n). Likewise, human actions (o) will be driven by an individual's personal conscious paradigm. Both chimps and humans will have their VR personal conscious paradigm experience of reality, but a human's experience is processed through its story cognitive module which will infuse narrative meaning on every conscious hallucination generated and thus will drive actions based on narrative beliefs. A human will live his whole life experiencing life in narratives and making beliefs out of narratives and acting out of those beliefs. But a chimp has no narrative experience of reality and no beliefs, living much more connected to the direct sensory input and takes action based on its instinctual response to the world around them. As historian Yuval Noah Harari writes "You could never convince a monkey to give you a banana by promising him limitless bananas after death in monkey heaven" (Harari, 2014, p.33).

The final part of the proposed human cognitive model is the community story system (labeled (4) in figure 1). Story is primarily a system of sharing information about what happened or how to understand something but is meaningless outside of the context of the community members who share the story. The human brain evolved with language and story shared through oral and gestural communication. So, the storytelling module is shaped by the spoken language of a given culture to keep the storylines in the oral memory banks of multiple community members. The information is transferred through storytelling as stories are repeated throughout years and among generations of community members. The keepers of the storylines are the keepers of a culture's knowledge. Storytelling is the cultural information system of a society and the common thread to song, music, dance, and ritual making. Stories are the mechanisms through which a society works together on larger tasks such as facilitating a tribal group's ability to hunt and forage, an agrarian society's ability to coordinate agricultural production or larger social projects of civilizations such as road making or going to war. The cultural information system of story is the engine through which collective learning is manifest. Science writer Gia Vince captures the essence of stories nicely:

> "[stories] work as collective memory banks, storing detailed cultural information encoded in narrative. Stories help cultural knowledge to linger in the collective memory long enough to accumulate and evolve, and they provide a reliable energy-efficient way of transmitting complex, context rich cultural information widely. As human cultural adaptation-our brains evolved with reflexive use of narrative as part of our cognition. Stories shaped our minds, our societies, and our interaction with the environment. Stories saved our lives." (Vince, 2020, p.82)

Once humans could cognitively model narrative explanations of our experience through storytelling, we could leverage our unique communication system to transmit complex information about phenomena and actions experienced by an individual to result in a meaningful response by others in the community who received that information. As the human storytelling/listening brain evolved in complexity it would have eventually reached a stage of awareness and understanding of characters and actions that one's own life would be experienced as a real time story where one's ego becomes the protagonist of their own life narrative as in a role-playing video game (RPG). This might suggest that human consciousness itself may be a variation of the storytelling reality modeling cognitive circuitry.

An Emerging Science of Storytelling

As far as we know, humans are the only species that has anything like this ability for cognitive narrative explanatory modeling of reality. Storytelling has emerged as something novel among the earth's species and has opened a whole new set of subsequent emergent possibilities through cultural evolution. As a thought experiment, the incremental development of storytelling as a driver of human evolution may be worthy of discourse among big historians, but what evidence is there to support the proposition that storytelling is central to what makes humans human? Over the past several decades many different lines of research

from widely divergent fields have provided compelling components to what may be emerging as a transdisciplinary science of storytelling.

The study of primate communication among homo sapien's closest biological cousins as previously referenced provides a starting point since the earliest hominins would have likely had a similar cognitive capacity. While there is likely no direct archeological evidence that can trace the evolution of combining word clusters into narratives, computer simulations suggest that the ability for symbolic communication could have emerged spontaneously under natural selection (Grouchy et al., 2016). Researchers are using techniques on the modern human brain such as fMRI brain scans of subjects recreating increasingly sophisticated stone tools to suggest neural representation of action grammars of human behavior implying incremental coevolution of language and technology (Stout et al., 2021, Arbib et al., 2023).

Fisher (2006) presents a "narrative intelligence hypothesis," suggesting that storytelling and symbolic thought were key factors in human evolution, enabling the transmission of complex information and facilitating cooperation. Storytelling and imaginative abilities would have been selected for during human evolution, contributing to our cognitive and social development (Lombardo, 2008). Barham & Everett (2021) make the case for the deep evolutionary foundation for hominin symbol use concluding that symbol-based language is expressed materially in arbitrary social conventions that permeate the technologies of Homo erectus and its descendants. Deacon (1997) investigated the co-evolution of language, storytelling, and the human brain arguing that storytelling played a central role in the development of symbolic thinking and the unique cognitive abilities of humans. Salillas (2021) explored the evolutionary roots of storytelling and its adaptive functions discussing how storytelling enhances social cognition, fosters cooperation, and transmits cultural knowledge across generations. Hogan (2011) explores the universality of narrative structures and their connections to human emotions. Gottschall and Wilson (2005) delve into the evolutionary significance of storytelling, arguing that narratives have played an important role in shaping human behavior and culture.

Stephen Pinker (1997) in his influential book explored various aspects of human cognition, including language and storytelling, from an evolutionary perspective, offering insights into the adaptive functions of narrative. Boyd and Richerson (1985) explore the role of cultural evolution in human adaptation, shedding light on how storytelling could have contributed to the transmission of cultural knowledge and cooperation within groups. They refined their concepts (Richerson & Boyd, 2005) by exploring the interplay between genes and culture in human evolution, emphasizing the importance of cultural transmission, including storytelling, in shaping human behavior and societies. Boyd (2009) expanded on the evolutionary significance of storytelling and argued that narratives have played a crucial role in human cognitive development, social cohesion, and cultural transmission. McAdams (2018) discusses the role of narrative identity in human development, connecting it to the evolution of storytelling as a mechanism for constructing and transmitting personal and collective narratives.

Robin Dunbar (2004, 1996) explored the role of gossip, which often takes the form of storytelling, focusing on its prominence in human social interactions and its evolutionary functions in building social networks, enforcing norms, and sharing information. He argues that storytelling and gossip have contributed to the cohesiveness of human groups and the development of social bonds (Dunbar, 2014). In a similar vein, historian Yuval Noah Harari, has emphasized that storytelling is an intrinsic part of human nature and a driving force in the development of civilizations. Harari explores how humans have used shared myths, narratives, and stories to create cohesive societies, coordinate in large groups, and construct complex belief systems. Harari suggests that our ability to create and believe in fictional narratives has enabled the formation of imagined orders, such as religions, nations, and economic systems, which have had a profound impact on human history (Harari, 2014).

The psychological investigation of the narrative representations in the modern human psyche was first explored by the Swiss psychologist Carl Jung. Jung established the concepts of archetypes as the instinctual psychic models of images, character roles, behaviors, and personalities that are universal, innate, and symbolic patterns or images and underlie the unconscious of all people and influence human behavior (Jung, 1968). To Jung, archetypes undergird an individual's psyche conceptualization of the world, structure conscious as well as unconscious behaviors and are manifest in individual dreams as well as the social building blocks of cultural mythologies that are fundamental to bond all societies. As

such archetypes play a deep role in the narrative cognitive modeling of the brain. Examples of archetypes include the hero and the hero's journey, the villain, the mother, the warrior, the idea of death etc. Jung described these instinctual archetypal characters and plots as universal to all people and living within not only the individual human psyche but also within a shared collective unconscious which he believed was a reservoir of inherited experiences and wisdom accumulated over the course of human evolution (Jung, 1969; Neumann, 1974). Likewise, for the theory of mind (Premack & Woodruff, 1978) who identified the unique aptitudes of one individual to understand and put themselves in the place what another is thinking may be another extension of the storytelling/listening cognitive modeling circuitry. As such, theory of mind would be the ability for one's own internal narrative model to mirror and comprehend the narrative experience of another.

Joseph Campbell (Campbell, 2008; Campbell & Campbell, 1969) expanded on Jung's ideas of archetypes within mythology through comparative study of mythologies of world cultures. Campbell revealed the universal themes of the hero's journey and the monomyth themes that run through all cultures. Campbell theorized four functions of myths to ground members of a society in mystical, cosmological, sociological and/or pedagogical/ psychological orders of humankind. Campbell's work influenced a whole generation of contemporary storytellers and was most notably George Lucas' inspiration for the Star Wars epic.

Since storytelling requires a community of story listeners, the most significant level for a story to be relevant is at the social level of the community with which one shares the stories. For the vast majority of time that homo sapiens have been around, that group of shared stories would be the local tribal community. All the story themes, plots and characters and meanings would have been shared among the tribal group. When narrative archetypes are shared it is the most profound social bond. Storytelling among a society creates a shared connection of individuals to their community and their ancestors. Shared cultural stories create a sense of shared reality, meaning and purpose.

Over most of the time that humans have been in existence we have been a tribal, mythological oral storytelling-based species. Today's brain is still biologically rooted in the archetypal tribal oral storytelling/listening process. Modern cognitive science is providing a lot of insight into the storytelling processes upon which our brains still are based. The fascinating phenomenon of speaker-listener neural coupling (Stephens et al., 2010) underscores the deep neural connection established between storytellers and their audience, shedding light on the intricate mechanisms behind effective communication and the shared understanding of narratives. Other research exploring the neural mechanisms underlying social interactions is revealing a coupled dynamics framework for understanding how shared neural patterns contribute to communication and empathy (Hasson & Frith, 2016, Nummenmaa et al., 2008).

Other researchers have leveraged fMRI and PET brain scans to unravel the neural underpinnings of language processing and storytelling. Price (2012) reviews two decades of brain scan studies on language processing covering a range of methodologies and providing a valuable context of research in mapping the brain's language functions. Huth et al. (2016) identified distinct brain regions responsible for various language components, including semantics, syntax, and phonology. Their research used fMRI to create an atlas of where the brain stores words by mapping the cerebral blood flow across the brain while test subjects were listening to a storytelling podcast called the "Moth Radio Hour". The work revealed the distributed nature of language processing, illustrating the coordinated activity of multiple brain areas to enable our complex linguistic abilities. What was most striking about this study was that while each of the thousands of individual words were mapped to a relatively small but unique spatial patterns of brain activity, the entire brain was essentially engaged at some point during the storytelling episode suggesting that the cognitive circuitry for storytelling requires a brain as large and complex as the modern human brain to tell stories at the modern level of complexity.

Other areas in which the storytelling nature of humanity is prominent includes the humanities, communications and performing arts suggesting that storytelling is more central to defining the human species than has been generally emphasized to date. Like the transdisciplinary nature of Big History which makes large scale connections between many different disciplines across the natural sciences, social sciences and humanities, the transdisciplinary nature of storytelling science also draws from widely divergent fields from cognitive sciences to anthropology to social sciences to humanities and performing arts. In fact, there does not appear, as of yet, to be an organized coordination of storytelling sciences at the larger scale which might

suggest, considering the deep synergies, that Big History could be an academic home for storytelling science.

The Synergistic Nexus of Storytelling and Collective Learning

If storytelling is so central to how the human brain conceptualizes the world and storytelling provides the mechanisms through which societies collectively work together then what is the relationship of storytelling to collective learning in the Big History framework and how does storytelling begin to fill in the "big blank spot on the collective learning map" (Baker, 2015b, p.304)? As discussed early in the paper, collective learning happens when information, knowledge and wisdom accumulates and disperses among members of a society and/or between generations. But collective learning cannot occur without an underlying apparatus to allow the information to be captured, stored and disseminated. A successful collective learning system would by design necessitate a mechanism for:

- information collection
- information conceptualization into useful knowledge
- Information distillation into experience
- information storage and retrieval
- generation of wisdom
- development of meaning
- transfer between information keepers
- knowledge dissemination to the community
- cultural motivation for agency and action.

All these functions are performed by storytelling, which provides the cultural human information system that facilitates collective learning to take place. David Christian describes how collective learning can be understood as a variant of a learning machine that has emerged as a manifestation of the universal Darwinism of information. "Universal Darwinism builds complexity by accumulating, storing and disseminating information about how to make things that work" (Christian, 2015, p.67). Christian goes on to describe how collective learning is the third informational variant to emerge nested on top of 'individual learning' of an organism in which knowledge is accumulated in an individual from direct experience which in turn is nested on top of the 'genetic learning and natural selection' information acquisition coded in the DNA of all living organisms.

Storytelling folds into this as the information engine underlying collective learning in its role as a third information machine variant. Figure 3 illustrates how storytelling provides the information subsystems that undergirds the collective learning process. For each improvement of the storytelling brain and/or each improvement in effectiveness of a storyline for collecting, conceptualizing, transmitting, making meaning and acting on the narration, the potential for collective learning would increase. As collective learning increases a society's understanding of how their world works or how to better coordinate among members, a community can leverage that knowledge for new emergent cultural expressions. In this manner cultures evolve and diversify with story as the glue holding a society together. This in turn results in cultures differentiating as their histories unfold from the pallet of historic possibilities provided by the synergistic nexus of storytelling and collective learning.

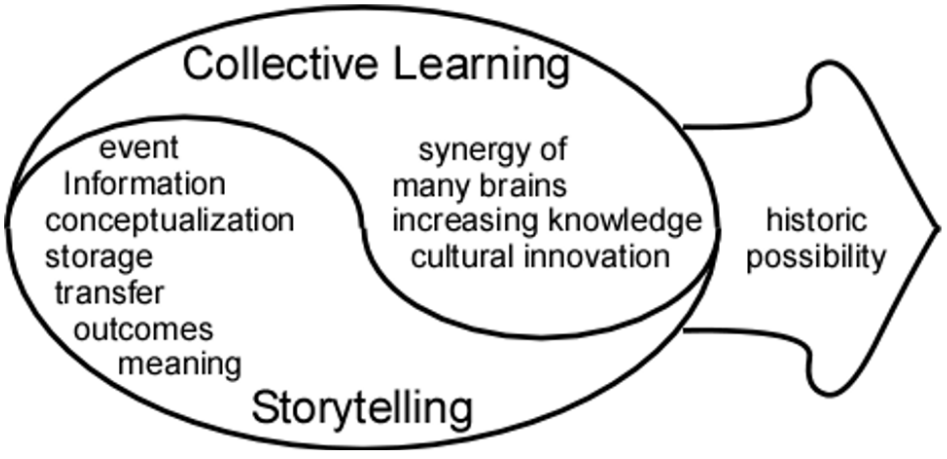


Figure 3. The synergistic nexus of storytelling and collective learning.

Note: Storytelling provides the information system by which collective learning can be manifest. In turn the state of collective knowledge of a society drives the possibilities of cultural evolution (i.e., history).

To illustrate, all living organisms respond to the events and stimuli with biological information. A human child may skin their knee and the body's biological information system immediately clicks into gear with a healing response. This is the first information machine variant is based on genetic information. The child will remember their direct experience of the event to avoid repeating the circumstance that led to the injury. This personal learning within the memory of the child would represent a second level information machine. A chimp child would have the same two levels of information machine at play. But non-present members of the chimp group would not have access to the event or be able to benefit from learned experience of the event. In contrast, when the little human child tells the story of what took place that resulted in the knee scrape to another member of the community, the occurrence can be shared with and understood by non-present members and the beginnings of collective learning take hold. With the telling of stories, events are explained and processed and made meaningful. If the storyline is successful at conceptualizing and making useful knowledge out of the event that is subsequently shared with others, the process of collective learning takes place. Storytelling is the mechanism that facilitates collective learning rising to a level 3 Darwinian information machine. For the vast majority of time that humans have had the capacity to tell and listen to stories, cultural information would be manifest within storylines orally passed between generations serving as memetic code for cultural evolution. Since the information system is oral based, each time a story is told some details may be lost while others may be embellished. In this Darwinian manner, the most universally relevant aspects of the story would be propagated, and least significant details would eventually drop out.

The evolution of storytelling and thus its corresponding level of collective learning would have occurred very slowly at first since it required the physical development of the storytelling brain to model the world in narrative thought. The brain would have to develop neural pathways and cognitive models to represent agents, settings, events, outcomes as well as enhanced memory and image processing of not just what one sees but the mental visualization of imagery generated by story. One can only speculate about the exact sequence of the evolution and pace of the storytelling capacity in any given hominin ancestor. Perhaps it would have an analog in the development of the storytelling capacity of a modern-day child. During its first few years, a human child progresses through multiple stages of language development going from pre-linguistic coos and cries to full grammatical fluency in which they become articulate storytellers/listeners. For example, a child begins to understand simple baby stories in their first year, begins to talk in their second year, begins to acquire the ability to understand the mental states of others (i.e., theory of mind (Leslie, 1987)) at about four years followed by an increasing ability to understand false beliefs between the ages of 4-6 years old. When each of these stages would have been first manifest in hominin development is difficult to say but must have happened sequentially. As such human storytelling capabilities throughout hominin evolution would have had to go through a similar set of storytelling capacity advances.

The stage of storytelling capacity and corresponding level of collective learning could perhaps be inferred by the size and morphology of the brain, the sophistication of tool making, the advancing ability to scavenge and hunt, the degree of migration into different environments, the mastery of fire etc. These are all prehistorical outcomes of collective learning in the story of humanity that would be rooted in the storytelling information system that underlies collective learning. In addition, throughout prehistory the evolutionary drive for better storytelling that could transfer increasingly complex knowledge more efficiently probably resulted in the brain's architecture employing many heuristics, or mental shortcuts, to simplify the many complex cognitive storytelling tasks. While there have been dozens of these cognitive biases identified such as confirmation bias and overconfidence bias (Tversky & Kahneman, 1974) that may or may not be associated with the evolution of storytelling neurological functionality, these cognitive biases must have been relatively benign and may have even had some pro-positive outcomes (e.g. faster decision making) in the context of the prehistoric storytelling capabilities lest they would have been evolved out of the system for their negative impact. Once storytelling capabilities become driven more by rapidly changing cultural factors than biological factors, we can see that cognitive biases do not have time to evolve out of the system and may become potential liabilities for being manipulated in pending cultural stages of storytelling evolution.

Nevertheless, over the early paleolithic, as more complex and refined storytelling capabilities emerged through the biological evolution of the underlying cognitive pathways,

the ratchet of collective learning and cultural evolution would have incrementally notched higher. In the later paleolithic, cultural innovations and progression would have eclipsed biological factors in influencing storytelling capabilities. Cultural factors influencing storytelling would have included increased migration and trade, development of song and dance, graphic abstractions of story in art on cave walls and pottery etc. Such cultural factors would all have amplified the pace of the evolving sophistication of storytelling and the corresponding level of collective learning. Increasing levels of collective learning would have resulted in further accumulation of knowledge and subsequent cultural complexification as well as more efficient exploitation of the environment for survival. Refined hunting technologies and strategies probably gave advantage to homo sapiens over Neanderthals and Denisovans as well as factored in megafauna extinctions. Eventually population pressures and changing climates required new levels of storytelling and corresponding collective learning resulting in the development of agriculture (BH Threshold 7) in the neolithic revolution. As population subsequently increased and concentrated in settlements, the ratchet of cultural evolution would have continued to notch yet tighter leading to the mini-threshold of civilization with the advent of the bronze age and the invention of writing.

Throughout the paleolithic, storytelling would have been an organic, life-enhancing, and symbiotic part of human behavior. Storytelling that was out of step with the knowledge needed to survive in a given ecosystem would not last long. Storytelling that transferred pro-positive behaviors that fostered survival within the environments in which a society lived would have had the highest chances for survival, stories replicated, and the collective knowledge passed down through successive generations. The paleolithic storytelling brain functioned brilliantly considering the multiple climatic changes it endured with successive ice ages and global migration throughout all corners of the world. The modern human storytelling brain has probably had very little biological change since the paleolithic.

With the advent of agriculture in the neolithic, storytelling would have had a major transformation. Instead of stories that taught how to survive within the carrying capacity of the wild ecosystem, neolithic storytelling would have shifted to teach how to domesticate and exploit resources to a much higher level than was possible with foraging. Storytelling itself would have transformed from a symbiotic process of individual personal relationship to a community and the natural world to a domesticated form of storytelling where stories were used to exploit the resources of the natural world as well as exploit the collective labor needed for the work-intensive labor of agriculture.

A phase change in storytelling was reached with the advent of civilization and the onset of writing in the bronze age. Storytelling would leap from being primarily orally-based within small groups that organically evolved from one generation to the next to being something captured permanently in written script and controlled by a relatively small group of elites. Writing was the first transformational technology that created a foundational transition in storytelling processes with equally transformational impacts on collective learning. Writing, however, was only a precursor to many additional changes in communication technology that will prove to impact storytelling capabilities and have consequences for collective learning outcomes including innovations such as the printing press, radio, TV, internet, etc. However, we will stay focused on the prehistoric period of storytelling/collective learning for the remainder of this paper and save post civilization for future writing.

The Prehistory Collective Learning Bathtub

David Christian (2015) evoked the image of a bathtub for conceptualizing the incrementally rising level of collective learning. The drain at the bottom of the tub would be left unplugged representing the fact that some cultural knowledge is continually lost over time within any given culture. However, as the flow of new cultural information increased faster than it drained, the level of collective learning would rise to new levels until it eventually overflowed the tub. I have expanded on the Christian collective learning bathtub by integrating the role of storytelling as a synergistic compliment necessary for the rising level of collective learning to occur. For the framework of this paper, I focus on the prehistoric period since storytelling capacity is largely determined by the biological development of the brain whereas post-historical storytelling capacity shifts to be primarily culturally driven and warrants a separate treatment. As our human ancestors evolved the cognitive capacity of the brain to tell increasingly nuanced and complex stories, the collective knowledge in those stories could result in beneficial outcomes that would tighten the ratchet of cultural evolution.

In Figure 4 and Table 1, I've adapted Christian's bathtub idea to illustrate the process of the coevolution of storytelling and collective learning and the subsequent historical outcomes during the prehistoric. Throughout the paleolithic period, the storytelling stage and the subsequent level of collective learning would be primarily determined biologically by the functional state of our symbolic language system and the cognitive capacity of the brain to model explanatory narration. In this manner the level of collective learning would be determined by the sophistication of the storytelling capability throughout the span of hominin lineage. Stage 0 Storytelling would precede the beginnings of what we would consider functional storytelling and therefore would not yet have reached a minimum level of collected learning. The common ancestor of chimps and humans would be considered Stage 0 storytelling as would modern chimps today.

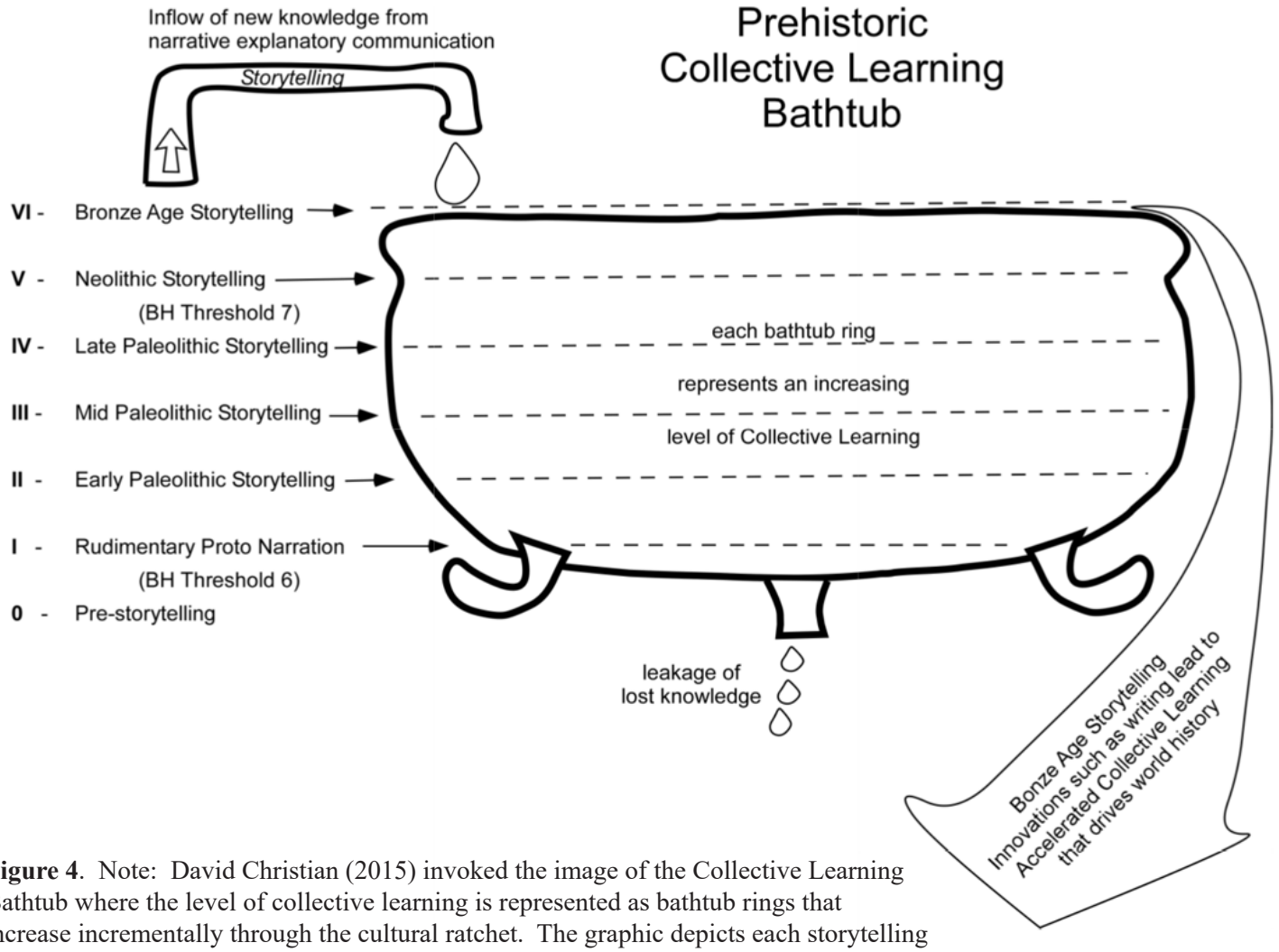


Figure 4. Note: David Christian (2015) invoked the image of the Collective Learning Bathtub where the level of collective learning is represented as bathtub rings that increase incrementally through the cultural ratchet. The graphic depicts each storytelling stage and its corresponding collective learning level in the tub. While some collective knowledge would leak out of the drain as there is an inevitable degree of cultural loss, the speed of the flow of new information would increase each time there was a shift in the storytelling capabilities that would allow better understanding, better retention, or more effective outcomes in using the knowledge for better surviving a changing environment. With the advent of the Bronze Age innovations in storytelling such as writing increase the pace of collective learning spilling over the tub into a different phase and driving world history.

Table 1. Stages of Prehistoric Storytelling-Collective Learning Coevolution

Storytelling Stage	**Storytelling Capability/ Milestone**	**Collective Learning Outcome**	**Selected Historical Consequence**
VI - Bronze Age Storytelling	writing trade networks social stratification money	civilization coercive power axial age social stratification bronze	City-states Uruk, Ur Thebes and Memphis Tyre Athens, Sparta
V - Neolithic Storytelling (BH Threshold 7)	narrative dissemination of agricultural practices agrarian mythology polytheistic religions concentrated village populations unify larger groups with common stories	farming knowledge lifestyle cultivation domestication permanent settlements loss of foraging cultural knowledge, beginnings of social specialization consensual power	Agricultural hearths Fertile Crescent Nile valley Indus Valley Huang He Valley Meso American and Andean Sub-Saharan Pacific Islands
IV - Late Paleolithic Storytelling	G3 grammar sophisticated story capabilities, theory of mind, deception animistic religions, tribal mythology	increasing pace of innovation - tools, art, hunting technique facilitate survival in changing climate	Sapiens displace Neanderthals and Denisovans - sapiens migrate around the globe. megafauna extinctions
III - Mid Paleolithic Storytelling	G2 grammar more nuanced abilities for explanatory narration	clothing, improving tool usage, scrappers, awls ornamentation, ritual burial, ice age survival	Neanderthals and Denisovans survive glacial fluctuations
II-Early Paleolithic Storytelling	G1 grammar common language shared among group	able to explain narrate important behaviors to group - fire usage, migration skills, raft building	Homo erectus migrates out of Africa into Asia develops fire usage hunting and cooking
I-Rudimentary Proto-narration (BH Threshold 6)	multi-word combinations can share info to third person	some info shared beyond observer allowing simple knowledge buildup	Homo habilis uses Oldowan stone tools, meat eating increases
O- Pre-storytelling (common ancestor w chimps)	none	none	behavior driven primarily by instinct

Note: This table presents a sketch of the Darwinian coevolution of storytelling and collective learning throughout the paleolithic period. Storytelling provides the information subsystems that facilitate collective learning in a synergistic relationship. As storytelling capabilities are incrementally improved through cognitive/cultural complexification, it facilitates the collective learning outcome resulting in possible influences on history. The table is not intended to be comprehensive but rather conceptual with many likely omissions and/or inaccuracies.

Once one of our human ancestors evolved the cognitive capacity for stringing enough words together to achieve the simplest of narrative communication Stage I Rudimentary Storytelling would have been reached and the most basic level of collective learning would have begun. One might speculate that it occurred with homo habilis since the first stone tool usage would imply a level of cognitive complexity that might be related to primitive proto-storytelling capability. I propose that the onset of Stage I Rudimentary Proto-Narration is where Big History Threshold (6) Human Emergence is located albeit would have been a subtle form of collective learning. Stage II Early Paleolithic Storytelling would have occurred when spoken language had reached a full spoken language with G1 grammar indicating some significant storytelling capability and thus a corresponding higher level of collective learning. I speculate that this would have occurred with homo erectus considering the feat of migrating out of Africa and into Asia, stone tool usage, and larger brain capacity are all indications that H. erectus had a reasonably sophisticated language (Everett, 2016) for functional storytelling.

In going from Stage II to Stage III - Mid Paleolithic Storytelling, grammatical complexity would have increased going from G1 to G2 grammar with Neanderthal and Denisovans. In this scenario, Neanderthals and Denisovans would have had at least a moderately well-developed storytelling capacity which would have resulted in a measurable increase in collective learning allowing learned behaviors for clothes making, complex hunting practices and possibly art and ritual burial (Pike et al., 2012; Rendu et al., 2014). In Stage IV - Late Paleolithic Storytelling, homo sapiens would have eventually had the most well-developed storytelling/collective learning capacity with full recursion of G3 grammar which in turn may have afforded them advantage in cultural knowledge that allowed them to displace Neanderthals in Europe (Villa & Roebroeks, 2014) and Denisovans in Asia (Higman, 2021). Stage IV storytelling would have been significantly more sophisticated enabling the development of collectively learned knowledge to guide homo sapiens to culturally evolve at a more rapid rate than any previous hominin and migrate to all major world zones.

Once homo sapiens spread throughout the globe and population began to reach the foraging carrying capacity of much of the world and assisted by the warming and stabilizing Holocene climate, the Paleolithic storytelling/listening brain was able to retool for Stage V - Neolithic Storytelling. Neolithic storytelling would have constituted a major mythological and cosmological phase change. Agriculture is a big deal in the story of the planet and is considered a major threshold (7) in Big History. Cosmology and mythology shifted from nature-based egalitarian community and animistic to seasonal farming and herding-based tribal stories where the divine plays the role of tending and overseeing people and the source of the harvest. The mythological stories of early agrarian period would have created a social identity of larger groups than previous paleolithic tribal societies. Neolithic stories would have had themes regarding the cycles of sowing and reaping, floods and famines and life in permanent settlements, social classes emerged with domesticated animals playing a significant role in the stories.

Stage VI Bronze Age Storytelling represents the beginning of civilization and an even larger phase change. Storytelling in this stage becomes primarily driven by cultural innovations rather than biological adaptation. The pace of collective learning becomes accelerated by cultural developments that impact the state of storytelling such as writing, money, social stratification, trade networks, and shared information. From this point on cultural change further accelerates and the prehistoric collective learning bathtub overflows. A completely different post-historical collective learning bathtub will have to be tackled in a future paper.

Students Storytellers in Teaching Big History

As the paper winds down, I'd like to circle back around to my Big History classroom where the seeds of this essay were planted. While the theorem sketched out in the pages above for a storytelling/collective learning nexus may or may not be found creditable historically or anthropologically, as a pedagogical framework for engaging students in the classroom, my colleagues and I have found that storytelling as a key concept for human emergence (BH Threshold 6) to compliment collective learning powerfully engages students on a personal level. I often ask my students if they can see examples of humans as a storytelling species reflected in the world as well as in their own lives and behaviors today. The discussion is usually revelatory and a eureka moment. Typically, students will start reflecting on how humans are storyteller by offering examples of the more traditional definition of storytelling such as "people love to watch movies and other performing arts which are stories" or "people read or watch

news stories to figure out what's happening in the world", "many religious beliefs are based on scriptural stories" or "people tell their daily personal stories on social media".

When I ask students to think about storytelling in the broader sense of 'explanatory narrative information sharing' students begin to see storytelling in many other places. Education is a form of storytelling; advertising is a form of storytelling. In a court of law lawyers tell stories about plaintiffs and defendants to convince a story-listening jury of guilt or innocence. Politicians are storytellers aiming to persuade story-listening voters of the benefits of their ideas or the flaws of their opponents. Science is a type of storytelling with specific rules that only allow empirical evidence, factual data, logic, and reason to be used to explain the nature of the natural world. Historians are storytellers of what happened in the past and geologists are storytellers of the earth's physical processes. Memoirs and biographies are stories of people's lives and obituaries are stories that capture who we were after we are gone. Students find storytelling in social media posts, the lyrics of their songs, in podcasts and in their video games. Gossip is one particular topic that students home in on explaining how prevalent it is for people to talk about other people behind their backs.

Some students have mentioned that the idea of seeing people as having storytelling minds has helped them put ideological polarization into a broader perspective explaining how different people can see the same event through completely unintelligible different narrative models. Students talk about how story gives meaning and makes one look deeper into our role as the storytelling species helping them to feel personally connected to the Big History of our planet. Students identify with the power of their own storytelling mind to keep them binge watching streaming serial videos from one episode to the next because their storytelling brain just has to know how the cliffhanger turned out.

One of the most consequential assignments for the course is an essay where students narrate their own life events and identify their own thresholds of complexity that have shaped them into who they are today. They become storytellers of their own little Big History and capture the essence of their own story placed within the framework of the Anthropocene. The assignment has been very popular and creates a sense of personal participation in the Anthropocene.

The past few paragraphs give a glimpse into how fruitful the theme of storytelling/story listening as a defining characteristic of humanity in the Big History has been in the classroom. While there is much more of a story to tell about this experience, this paper would be remiss without giving an indication about the remarkably positive pedagogical experience the storytelling/collective learning theme has been to myself and several colleagues. Storytelling powerfully engages students to relate their own life story to the narrative of Big History and tap David Christian's challenge for today's generation to embark on their own quest to navigate through a complex future into the Anthropocene.

Discussion - The Big So What

This paper has explored the idea of how the storytelling nature of humanity might contribute to the Big History concept of collective learning throughout prehistory as well as the pedagogical benefits of integrating storytelling into the Big History classroom. But does a storytelling framework have larger relevance for our current moment in time? If the human mind has evolved, in essence, to be a storytelling machine then understanding how that machine works and how storytelling motivates action and human agency is essential for humanity to figure out and Big History can play a major role in developing and disseminating that knowledge.

As of the writing of this paper, the world stands at a precarious set of social and environmental predicaments the outcomes of which could go in many directions and storytelling will be a central agent in how the future will unfold. Storytelling has the power to inspire courage, invoke creativity, and encourage perseverance by drawing on the archetypal hero's journey and the ability of stories to unify people to work toward common goals. At the same time, storytelling is vulnerable to being weaponized for nefarious purposes, to instill fear, exploit vulnerabilities and subjugate disenfranchised people. The Dark Art of Storytelling as Jonathan Gottschall calls it (2021) underlies the recent resurgence of authoritarianism through demagoguery, scapegoating, gas-lighting and political polarization, or outright historical erasure. Storytelling is used to generate false narratives and indoctrinate unfounded beliefs. Tiananmen Square never happened for young Chinese. The special military operation in Ukraine is not a war but an exercise to expunge Nazis and liberate the country. A certified secure election was unjustly stolen. Climate change is a hoax. New viral species of

storytelling enabled by the internet and accelerated through social media are allowing malignant storylines to spread around the world at the speed of light repeated over and over until the stories are burned into belief. State and corporate controlled media blast highly charged storylines into our vulnerable cognitively biased story brains that are biologically wired for a long past much simpler paleolithic reality to create insatiable demand for consumer goods or generate indignant anger for political engagement.

If storytelling is central to human cognition and the cultural engine through which humans collectively learn, coordinate collective social agency and drive history, then documenting the narratives, story lines, myths and the legends that underlie historical as well as current events is an essential task that the discipline of Big History is uniquely situated to perform. Big History can embrace storytelling across multiple disciplines over the longue durée of history and prehistory and provide a science-based perspective to chronicle how story has been used to coordinate, motivate, and coerce social behavior and how storytelling might reinvigorate its pro-social role. It's impossible for humanity to have a future void of story. Big History has a unique transdisciplinary vantage point to understand of the social implications of storytelling and can play an essential role in providing a storytelling theory that can possibly help provide an objective context for story to refill its symbiotic purpose.

If we are indeed at a Big History 9th Threshold of the Anthropocene, the directions that this threshold will take will be inextricably guided by the stories that we tell ourselves. If the Dark Storytelling holds the greatest sway, then the coming Anthropocene will likely be further socially and environmentally degraded. Conversely, if humanity can navigate through the turmoil, reject stories of fear, exploitation, hatred, over-consumption, and greed and embrace stories that promote truth telling, science, compassion, courage, stewardship, imagination and wisdom then the coming Anthropocene has much to be hopeful for. Big History has much to contribute to working toward the latter by offering the essential common origin story for unifying all of humanity to be able to manifest the most pro-future vision of a Good Anthropocene.

Finally circling back to the question of the significance of humanity as the storytelling species in the grand narrative of universal evolution, the invention of storytelling within the universe through the emergence of the human is on a similar magnitude of significance as to the invention of the first eye. 500 million years ago trilobites evolved a complex eye and for the first time the universe could begin to see what the universe looked like. Pre trilobite organisms could not imagine that light-based vision could exist let alone what the experience would be like. But with the trilobite eye a whole new level of experience was possible. Once storytelling is invented in the human, conscious awareness emerges within the universe allowing it to be conscious of what is happening and understand through symbolic thinking, comprehend knowledge, and employ wisdom. With storytelling, the universe has been able to document itself, tell its own story, understand its origin, and the Big History of how it got to be the way that it is today. The storytelling species is the first to celebrate existence, ponder its future prospects and make meaning. Through the imagination embodied within the storytelling human brain the universe is able to dream up entire new universes that never existed before and recreate from the residue of evidence worlds that have long since passed. That seems like a pretty big deal even on the scale of the whole universe. Even if other advanced forms of intelligent life are out there (and it seems to be statistically inevitable), it is unlikely that they will have an exact duplicate of the human narration-based consciousness that emanates out of our unique ability to tell stories. We are likely unique in all the universe and the potential for what is possible in the future of planet earth through the storytelling species should we successfully navigate our current predicaments are as unknowable, awesome and transformational to us now as was vision to sightless pre-trilobite organisms.

Conclusion

This paper has provided a sketch of an idea that has arisen through over a decade of teaching Big History at Rowan University that explores how collective learning is related to the storytelling nature of homo sapiens. It is an idea that is still under formation and this paper is a first attempt to share it more broadly with the Big History community as part of the re-examining fundamentals special edition of the Journal of Big History. The paper has attempted to make the case that storytelling is an essential emergent property of the human species and that it is a foundation of the collective learning engine that has driven history. If the idea merits further interest, there is much more work to be done fleshing out details, filling in gaps and testing the inherent speculations. The paper invites the Big History community to consider the role of storytelling science as

a uniquely transdisciplinary area of exploration that can find a home within the Big History tent, pull together many diverse Big History threads and help to tell Big History more effectively as a common human origin story for navigating the precarious prospects of the Anthropocene that lie ahead.

References

Arbib, M. A., Fragaszy, D. M., Healy, S. D., & Stout, D. (2023). Tooling and construction: From nut-cracking and stone-tool making to bird nests and language. *Current Research in Behavioral Sciences*, 100121.

Azevedo, F. A., Carvalho, L. R., Grinberg, L. T., Farfel, J. M., Ferretti, R. E., Leite, R. E., ... & Herculano-Houzel, S. (2009). Equal numbers of neuronal and nonneuronal cells make the human brain an isometrically scaled-up primate brain. *Journal of Comparative Neurology*, 513(5), 532-541.

Baker, D. (2016). Collective learning: A potential unifying theme of human history. *Journal of World History*, *26*(1), 77-104.

Baker, D. (2015a). Collective learning as a key concept in big history. *Evolution: From Big Bang to Nanorobots*, *81*.

Baker, D. (2015b). Standing on the shoulders of giants: Collective learning as a key concept in big history. *Globalistics and Globalization Studies: Big History & Global History. Yearbook/Edited by*, 301.

Barham, L., & Everett, D. (2021). Semiotics and the origin of language in the lower paleolithic. *Journal of Archaeological Method and Theory*, 28(2), 535-579.

Boyd, B. (2009). *On the origin of stories: Evolution, cognition, and fiction*. Harvard University Press.

Boyd, B., & Richerson, P. J. (1985). *Culture and the evolutionary process*. University of Chicago Press.

Campbell, J. (2008). *The hero with a thousand faces* (Vol. 17). New World Library.

Campbell, J., & Campbell, J. (1969). *The masks of God: Primitive mythology* (p. 278). New York: Viking Press.

Christian, D. (2018). *Origin story: A big history of everything*. Little, Brown Spark.

Christian, D. (2017). What is big history? *Journal of Big History*, *1*(1), 4-19.

Christian, D. (2015). Part II. Global history and modernity swimming upstream: Universal Darwinism and human history. *Globalistics and Globalization Studies: Big History & Global History*, 138-154.

Christian, D. (2011). *Maps of time: An introduction to big history* (Vol. 2). Univ of California Press.

Christian, D. (1991). The case for" big history". *Journal of World History*, *2*(2), 223-238.

Christian, D., Stokes Brown, C., & Benjamin, C. (2014). *Big history: between nothing and everything*. McGraw Hill.

Cloud, P. (1980). *Cosmos, earth, and man: a short history of the universe*. *Cosmos*.

Deacon, T. W. (1997). *The symbolic species: The co-evolution of language and the brain*. W. W. Norton & Company.

Dennett, D. C. (2017). *From bacteria to Bach and back: The evolution of minds*. WW Norton & Company.

Dennett, D. C. (1995). *Darwin's dangerous idea: Evolution and the meanings of life*. Simon & Schuster.

Dunbar, R. I. (1996). *Grooming, gossip, and the evolution of language*. Harvard University Press.

Dunbar, R. I. (2004). Gossip in evolutionary perspective. *Review of General Psychology*, 8(2), 100-110.

Dunbar, R. I. (2014). *Human evolution: A pelican introduction*. Penguin UK.

Everett, D. L. (2016). *How language began: The story of humanity's greatest invention*. W. W. Norton & Company.

Fisher, J. (2006). *The first idea: How symbols, language, and intelligence evolved from our primate ancestors to modern humans*. Macmillan.

Goodall, J. (1986). *The chimpanzees of Gombe: Patterns of Behavior*. Harvard University Press.

Goodall, J. (2010). *Through a window: My thirty years with the chimpanzees of Gombe*. HMH.

Gottschall, J. (2021). *The story paradox: how our love of storytelling builds societies and tears them down*. Hachette UK.

Gottschall, J. (2012). *The storytelling animal: How stories make us human*. Houghton Mifflin Harcourt.

Gottschall, J., & Wilson, D. S. (2005). *The literary animal: Evolution and the nature of narrative*. Northwestern University Press.

Grouchy, P., D'Eleuterio, G. M., Christiansen, M. H., & Lipson, H. (2016). On the evolutionary origin of symbolic communication. *Scientific reports*, 6(1), 34615.

Harari, Y. N. (2014). *Sapiens: A brief history of humankind*. Random House.

Hasson, U., & Frith, C. D. (2016). Mirroring and beyond: Coupled dynamics as a generalized framework for un-

derstanding and modulating social interactions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 371(1693), 20150366.

Higham, T. (2021). *The world before us: The new science behind our human origins*. Yale University Press.

Hobaiter, C., & Byrne, R. W. (2011). The gestural repertoire of the wild bonobo (Pan paniscus): A mutually understood communication system. *Animal Cognition*, 14(6), 745-767.

Hobaiter, C., & Byrne, R. W. (2014). The meanings of chimpanzee gestures. *Current Biology*, *24*(14), 1596-1600.

Huth, A. G., de Heer, W. A., Griffiths, T. L., Theunissen, F. E., & Gallant, J. L. (2016). Natural speech reveals the semantic maps that tile human cerebral cortex. *Nature*, 532(7600), 453-458.

Jantsch, E. (1980). *The self-organizing universe: Scientific and human implications of the emerging paradigm of evolution*.

Jung, C. G. (1968). *Man and his symbols*. Dell.

Jung, C. G. (1969). *The archetypes and the collective unconscious*. Routledge.

King, B. J. (2016). Animal mourning: Précis of how animals grieve (King 2013). *Animal Sentience*, *1*(4), 1.

Leslie, A. M. (1987). Pretense and representation: The origins of "theory of mind". *Psychological Review*, 94(4), 412-426.

McAdams, D. P. (2018). *The art and science of personality development*. Guilford Publications.

Moore, R. (2016). Meaning and ostension in great ape gestural communication. *Animal Cognition*, *19*(1), 223-231.

Moss, C. (2012). *Elephant memories: Thirteen years in the life of an elephant family*. University of Chicago Press.

Neumann, E. (1974). *The origins and history of consciousness*. Princeton University Press.

Nummenmaa, L., Hirvonen, J., Parkkola, R., & Hietanen, J. K. (2008). Is emotional contagion special? An fMRI study on neural systems for affective and cognitive empathy.

Pike, A. W., Hoffmann, D. L., García-Diez, M., Pettitt, P. B., Alcolea, J., De Balbín, R., ... & Zilhão, J. (2012). U-series dating of Paleolithic art in 11 caves in Spain. *Science*, 336(6087), 1409-1413.

Pinker, S. (2015). *Words and rules: The ingredients of language*. Basic Books.

Pinker, S. (1997). *How the mind works*. W. W. Norton & Company.

Pinker, S. (1994). *The language instinct*: How the mind creates. *Language. New York: Harper Collins*.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind?. *Behavioral and brain sciences*, *1*(4), 515-526.

Rendu, W., Beauval, C., Crevecoeur, I., Bayle, P., Balzeau, A., Bismuth, T., ... & Goval, E. (2014). Evidence supporting an intentional Neandertal burial at La Chapelle-aux-Saints. *Proceedings of the National Academy of Sciences*, 111(1), 81-86.

Richerson, P. J., & Boyd, R. (2005). *Not by genes alone: How culture transformed human evolution*. University of Chicago Press.

Sagan, C. (1980). Cosmos. Random House.

Salillas, E. (2021). The role of storytelling in human evolution. *Evolutionary studies in imaginative culture*, 5(1), 83-98.

Savage-Rumbaugh, E. S., McDonald, K., Sevcik, R. A., Hopkins, W. D., & Rubert, E. (1986). Spontaneous symbol acquisition and communicative use by pygmy chimpanzees (Pan paniscus). *Journal of Experimental Psychology*: General, 115(3), 211-235.

Schel, A. M., Townsend, S. W., Machanda, Z., Zuberbühler, K., & Slocombe, K. E. (2013). Chimpanzee alarm call production meets key criteria for intentionality. *PloS one*, 8(10), e76674.

Spier, F. (2022). Thresholds of increasing complexity in big history: A critical review. *Journal of Big History*, *5*(1).

Stephens, G. J., Silbert, L. J., & Hasson, U. (2010). Speaker–listener neural coupling underlies successful communication. *Proceedings of the National Academy of Sciences*, 107(32), 14425-14430.

Storr, W. (2020). *The science of storytelling: Why stories make us human and how to tell them better*. Abrams.

Stout, D., Chaminade, T., Apel, J., Shafti, A., & Faisal, A. A. (2021). The measurement, evolution, and neural representation of action grammars of human behavior. *Scientific Reports*, 11(1), 13720.

Swimme, B., & Berry, T. M. (1992). *The universe story: from the primordial flaring forth to the ecozoic era--a celebration of the unfolding of the cosmos*. HarperCollins, *NY*.

Townsend, S. W., Koski, S. E., Byrne, R. W., Slocombe, K. E., Bickel, B., Boeckle, M., ... & Manser, M. B. (2017). Exorcising G rice's ghost: An empirical approach to studying intentional communication in animals. *Biological Reviews*, *92*(3), 1427-1433.

Turner, A. H., Pol, D., Clarke, J. A., Erickson, G. M., & Norell, M. A. (2007). A basal dromaeosaurid and size evolution preceding avian flight. *Science*, 317(5843), 1378-1381.

Villa, P., & Roebroeks, W. (2014). Neanderthal demise: An archaeological analysis of the modern human superiority complex. *PLOS ONE*, 9(4), e96424.

Vince, G. (2019). *Transcendence: how humans evolved through fire, language, beauty, and time*. Penguin UK.

Zacks, J. M., Speer, N. K., Swallow, K. M., Braver, T. S., & Reynolds, J. R. (2007). Event perception: A mind-brain perspective. *Psychological Bulletin*, 133(2), 273-293.