The Third Age of Human Memory

While it is common to marvel at how our economy and culture have been changed by the tsunami of data unleashed by computers, the great potential of this emerging age of digital memory will not be realized until we at least try to understand the underlying question of how it is transforming information and our interaction with it. [1] [2] These changes present a dilemma because previous transitions have shown that every new communication technology is managed in the same manner as the older until experience teaches us how to exploit its unique capabilities. [3] [4] [5] [6]

In this, it will be helpful to keep in mind Marshall McLuhan's enigmatic aphorism that "the medium is the message" - which encompassed the insight that the content of every medium is another medium. Thus, where thought is the content of speech, speech is the content of writing. [7]

Although studies show that infants intuitively learn spoken language [8] there must have been a time when information sharing was limited to what could be conveyed through mimetic communication, which includes gestures, facial expressions, and vocal intonation. [9] [10] [11] [12] [13] Even today it continues to play an important role in social interaction and communication, [14] [15] [16] and is being studied as an efficient computational strategy for extending learning to physical human–robot interaction. [17] [18] [19]

Some studies hint at the possibility that social media applications (such as Facebook) [20] [21] are popular because they evoke communication and cultural habits presumed to have been developed during the period in which spoken language emerged out of mimetic communication. [22] [23]

The origin of spoken language can only be guessed because speech does not leave fossils. [24] [25] However, in 1767 [26] (nine years before his better remembered *Wealth of Nations*) Adam Smith speculated that it developed as people endeavored to make their mutual wants intelligible by uttering certain sounds which became accepted as symbols for the objects or thoughts they referred to. [27]

It has been suggested that those symbolic sounds became the first words, and that each word serves as a metaphor associating all related perceptions. [28] [29] [30] [31] That first step was critical because what is not symbolically represented cannot be communicated. Creation of a vocabulary (lexicon) provided both the necessary symbols and their meanings (semantics) needed to model the world. [32]

Even without spoken language every individual can learn through observation and experience, [33] but speech established a network harnessing the synergy of many brains by assembling individual knowledge into a community memory that could be shared and preserved through future generations. [34] Studies show that spoken language has a greater information density than mimetic communication, and that it improved the efficiency of pedagogy - the art of teaching. [35]

Our ancestors lived in small nomadic hunter-gatherer groups where cooperative activities, including coordinated group hunting, the manufacture of stone tools, and the use of fire provided advantages in the struggle for survival. [36] Indeed, Jean-Jacques Rousseau (1712-1778) asked how many times the creation and use of fire had been learned, only to die with its discoverer before language was available to pass that knowledge to future generations. [37]

McLuhan wrote that spoken language "was the first technology by which man was able to let go of his environment in order to grasp it in a new way." [38] Perhaps this is because words, as abstractions of what they represent, promote abstract thought. [39] [40] [41] [42] As observed in 1769 by the French Encyclopedist Denis Diderot, when people "are endowed with memory, they can think." [43]

Marcus Fabius Quintilianus (c. 35 – c. 100 AD), a Roman rhetorician, observed that "Nearly everything we say is a metaphor" [44] and Robert Frost stated that "Nearly everything we say has a metaphorical basis." [45]

Words also provided an intuitive system for classification. [46] [47] [48] [49] [50] [51] Socrates advised that a man must "be able to define everything separately; then when he has defined them, he must know how to divide them by classes until further division is impossible." [52]

It has been suggested that the categories introduced by Aristotle (384–322 BC) were the beginning of scientific language and influenced thinking into the Renaissance. [53] Aristotle's enduring influence is shown by the fact that even in 1583 students and faculty at Oxford University could be fined five shillings for every point of divergence from him. [54]

During that first age of human memory, when preservation of knowledge was dependent on the memory of the living, storage and retrieval of information was enhanced through the mnemonic power of poetry and song. [55] [56] [57] [58] [59]

Language allowed communities to specify preferred and prohibited behaviors defining their culture. [60] These were cast as metaphors and gathered into epics in poetic form (such as the Iliad and the Odyssey) that have been referred to as tribal encyclopedias used to preserve and teach cultural memory. [61] [62]

Hesiod, considered a contemporary of Homer, described the content of songs as "the custom-laws of all, and folkways of the immortals." [63] [64] [65] The value of song for information storage was also illustrated by Aristotle's comment that "before men knew the art of writing they used to sing their laws in order not to forget them." [66]

Both music and spoken language involve gesture and body movement, and (along with the language of mathematics) utilize recursion for generating an infinite number of expressions from a finite set of elements.[67]

Memory decays with time even when aided by poetry and song, and is prone to alteration driven by self-interest.[68] The introduction of written language about 5,000 years ago illustrated the Chinese proverb that the faintest ink is stronger than the best memory.

With the invention of writing human memory was no longer limited to the lifespan of the participants to a conversation. It achieved this by storing information in containers external to the brain, allowing it to be shared across time and space. The cognitive neuroscientist Merlin Donald labeled this External Symbolic System Storage (ESS), [69] and wrote that "...it must be regarded as a *hardware* change in human cognitive structure, albeit a nonbiological hardware change." [70]

In that transition the words and their meanings were carried into writing. The first use of this new technology included transcribing epic poems, thereby preserving cultural traditions. [71]

Socrates (469-399 BCE) warned that writing would cause forgetfulness because people "will trust to the external written characters and not remember of themselves." [72] Plato (student of Socrates) cautioned that "no intelligent man will ever be so bold as to put into language those things which his reason has contemplated, especially not into a form that is unalterable—which must be the case with what is expressed in written symbols." [73]

While there was a thriving book trade long before Johannes Gutenberg invented the printing press [74] each handwritten manuscript had been a separate and distinct edition of one, [75] which prevented reference to a standard text. [76] Every copy could have errors, with drawings and diagrams subject to even more rapid corruption than text. [77]

Production of manuscripts was slow, with a scribe requiring up to a year to copy a Bible. [78] By accelerating the speed of production the printing press increased the availability of books while reducing their cost.[79] During the early years of printing (called the *Incunabula* - Latin for cradle) the printing press spread rapidly and scholars have identified more than 40,000 different issues of books produced before 1500. [80]

Early printers published books that closely resembled manuscripts both because they were used as models and because printers were concerned over acceptance of this new technology by customers accustomed to buying handwritten books. [81] [82] Indeed, it is rumored that the first printed books to reach Paris were passed off as manuscripts. [83]

As part of this effort, type fonts were created to resemble the calligraphy of popular copyists. For example, Aldus Manutius (an influential printer in Venice from 1494 to his death in 1515) had Francisco da Bologna cut an Italic type copied on the style used by the papal chancery. [84] [85] Aldus used that condensed type to print small (and therefore cheaper) books that would fit into a pocket. [86] [87] Printers also began experimenting with innovations that might appeal to readers, including title pages, tables of content, and footnotes. [88] [89]

After the printing press made it possible to produce multiple identical copies people could share information with greater authority. [90] [91] [92] The resulting books from this stream of improved documentation contributed lasting additions to the accumulated memory of mankind.

The expanding volume of knowledge also led to an expanded lexicon [93] because, as explained by Niccolò Machiavelli (1469—1527), "whenever new ideas or new arts come to a place, new words necessarily come too." [94]

The first use of this new technology was to print popular manuscripts, primarily religious works and Greek and Roman classics. [95] [96] One Roman classic, *De Materia Medica* by Pedanius Dioscorides (c. 40 – 90 AD), describing about 600 plants useful as herbal medicine, had served as the chief botany text for more than 1,500 years. [97] Within the century and a half after the printing press made copies widely available the documentation of known plants had increased to more than 6,000. [98]

This rapid growth of new knowledge was of great benefit to Europeans during the Age of Exploration. For example, during his fourth voyage in 1504 Christopher Columbus secured an advantage while negotiating for provisions with the inhabitants of a village on Jamaica by referring to an astronomical almanac. Noting that a lunar eclipse would soon occur, Columbus threatened that God would punished the village with famine and pestilence unless they provided food. When the eclipse happened at the predicted time the village gave into his demands. [99]

We deride the faith of that age in the occult (Latin *occultus* = hidden) by forgetting that we can only know what can be measured. Before the microscope (1590) there was no reason to doubt that diseases were divine punishment for sin, [100] and before the telescope (1608) there was no reason to doubt that stars and comets were divine messages of future events. [101] [102]

Spoken communications are conducted in social situations during which words, selected on the fly, are defined by other words and the context in which they are used, [103] [104] [105] [106] [107] and the way a message is structured (syntax) can be quite fluid. [108] [109]

Communications through writing, however, encourage a deliberate, editable process promoting expressions of universal truths independent of the context in which they occur. [110] [111] [112] The larger lexicon and stricter syntax of written language give it a greater information density than spoken language. [113] [114] [115] [116]

Further, where spoken communications are often chaotic jumbles of ideas and opinions, written communications encourage linear presentations that clarify and systematize thoughts to support the logic and conclusion of a message. [117]

In stark contrast, our emerging age of digital memory is based on the language of mathematics. Developed perhaps 5,000 years ago to meet the needs of trade and taxation, [118] mathematics achieved a seminal advance in 1854 when George Boole, (referencing "the Logic of Aristotle"

[119]) showed how algebraic equations could be used to solve logical problems. In an earlier book, Boole wrote that this method of analysis depended upon the laws of combination (syntax), not the interpretation of the symbols used (semantics). [120]

In 1937 Claude Shannon showed how Boolean algebra could be used to design circuits, a solution that has been recognized as a fundamental concept underlying our emerging age of digital information. [121] His 1948 article "A Mathematical Theory of Communication" focused on how the statistical structure of a message could be used to optimize the quantity, and minimize the errors, of data when being transmitted in an electrical signal. [122] [123] [124] [125]

While this gives digital memory a much greater density than written language, it comes at a cost. Shannon wrote that the "semantic aspects of communication are irrelevant to the engineering problem." [126]

Where the semantics and syntax of spoken and written languages are relaxed, in the language of mathematics they are unambiguous. [127] Computers have been most useful with "structured data" - that is - numbers that can be stored and manipulated in relational databases and spreadsheets.

In computer science everything else is defined as "unstructured data" – including text, dialogue, poetry, videos, photos, and audio files. Since most estimates generally agree that this latter category comprises more than 80% of all information, it might be better defined as "unstructured information assets" in order to avoid the misapprehension that contemporary computer information management approaches can satisfy all of our information needs.

Beyond the differences of spoken, written, and mathematical languages, distinctions effected by technologies render our effort to manage this new digital information environment in the same manner as the predecessor paper-based world ineffectual.

When created, a printed item is a physical artifact that has a fixed and final form that can be described with lasting precision. For example, in 1623 a book of 36 plays by William Shakespeare, known as the First Folio, was published in a printing of perhaps 750 copies. In 2008, when someone walked into the Folger Library with an old book, staff of that renowned institution quickly identified it as the copy of the First Folio stolen from Durham University, England, in 1998.

The same characteristics that allowed scholars to identify the specific copy of a book printed nearly 400 years earlier allowed information during the age of printed memory to be managed by creating catalogues listing just a few characteristics of each printed item - generally title, author, and subject.

Our current effort to manage information in this emerging age of digital memory by using the meme published by Melville Dewey in 1876 [128] is ignoring the observation of the Library Archives Canada that computers have "thrown into question the notion of discrete, bounded

information resources" [129] and that current efforts, focused on retrofitting paper techniques to digital environments, are not sustainable. [130]

Instead of locking information into bounded information containers such as books, computers store data as pulses of energy spread around digital memory. Because of this, every discrete item of digital information is (at least theoretically) equidistant from every other discrete item of information.

When requested by users, the computer assembles those pulses into discrete items of information that, on a monitor or printed page, resemble the familiar physical artifacts from the age of written memory. However, they are so easy to edit that digital information assets will not have a final, stable version. [131]

Unless printed out as physical artifacts, digital "documents" are as ephemeral as spoken words that vanish with their sounds. As pointed out in a book on the foundations of digital evidence, computer files are pure information that "live apart from the world of artifacts" [132] and printed copies of a computer generated document are only "an original of what was printed out, not of the record of digital information." [133]

During the age of spoken language bards preserved and shared the knowledge of their communities. [134] During the age of printed memory librarians gathered and made available the accumulated memory of mankind. In this Digital Incunabula, the design of information systems has been conceded to information technology specialists who, using the language of mathematics, build systems focused on sets of structured data without considering how those systems fit into the corporate information environment - let alone the global information ecosystem.

This essentially ignores the vastly larger volume of unstructured information assets in the more relaxed semantics and syntax of spoken and written languages. Perhaps this is why one study of user information seeking behavior showed that those who view the Internet as a library had better results than those who view the Internet as a web, grid, or network. [135]

The human mind intuitively functions in the global information ecosystem where virtually every exchange of information utilizes erratic and intertwined streams of visual and verbal spurts of structured data, unstructured information assets, knowledge, and (sometimes) wisdom. The cognitive neuroscientist Merlin Donald wrote that "...the essential cognitive adaptation underlying each of the three great cognitive transitions in human evolution is a new system of memory representation." [136]

Those tasked with designing and implementing corporate information environments should step back and consider how best to design information systems that will function seamlessly within corporate information environments and support the native capacity of our minds to function

(and sometimes to thrive) in this rapidly growing superabundance of unstructured information assets and structured data.

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