

{Introduction}

The astonishing speed with which computers have become essential in our lives has instilled a presumption that the disciplines of computer science and information technology are the prime authorities on matters relating to information management. It has also shifted attention to the technical challenges of using digital devices, and away from designing information environments meeting the information needs of users within communities of interest.^{1 2}

In this early stage of our emerging age of ubiquitous computing, we need to engage in conversations about integrating digital memory and communication technology into our cognitive and communication toolbox to meet the full panoply of our information needs. The primary goals of these discussions must include identify additional disciplines that need to be involved in designing, implementing, and maintaining information environments.

In this we cannot ignore lessons from previous introductions of new communication and memory technologies. While an imperfect window, history is the only valid laboratory for examining the potential consequences of decisions.^{3 4 5}

One lesson is that instead of replacing previous language modalities, the newest technology^{6 7} becomes one more component of our increasingly complex and powerful cognitive and communication toolbox.⁸ Yet another lesson is that new media modalities are initially managed as the previous until experience demonstrates how to take advantage of their unique features and power.^{9 10 11}

One fundamental goal when designing information environments must be to make information available when needed, where needed, and in a format suitable for use.¹² While common sense instead of a measurable metric, it is the baseline reason we preserve information.

Another essential goal must be to examine how the digital revolution is impacting the factors that must be considered when designing a library. The image of a library (Latin *liber* = “book”) remains fixed in general usage as a physical building where book are stored for use. Even before computers this had become an amorphous concept as libraries offered reference services, videos, and other media.¹³

With the digital revolution and the Internet, it is now being applied as any place where information assets (independent of modality) are stored and available for use.^{14 15} Most definitions limit the label to entities having trained staffed, a curated collection, and provide assistance to users. The failure of the Internet to meet these essential elements caused one observer to write that calling the Internet a library is the equivalent of comparing a fleamarket to the Library of Congress.¹⁶

{Body}

{Evolutionary Chain of Languages}

Digital communication and memory technology the latest in an evolutionary chain of languages that includes speech, writing, and mathematics. In *The Sixth Language* (2004), Robert K. Logan, professor emeritus at the University of Toronto, posited that “Each (language) evolved from its predecessors as new information-processing needs emerged that preceding languages could not deal with effectively. Each builds on the features of its predecessors, while adding a number of new information processing elements of its own. Each new language eventually led to an information explosion and a new set of challenges that set the stage for the next level of development and the emergence of still another form of language.”¹⁷

{Language and Memory}

Although our minds can create memories (Latin *memoria* = faculty of remembering) without language (Old French *langage* = tongue)¹⁸ language would be impossible without memory.¹⁹

{Memory}

The Greek philosopher Socrates (469-399 BCE) described memory as a gift from Mnemosyne, the goddess of memory and mother of the Muses. He compared memory to a wax tablet on which people could record what they wanted to remember, but which could be erased or fade away.^{20 21}

That was an appropriate metaphor since wax tablets have been used for more than 4,000 years,²² ²³ were widely used in ancient Egypt, Greece, and Rome,^{24 25 26} and continued in common usage into the Late Middle Ages.²⁷

{Creating Memories}

Memories are created through a process that begins with ingestion of stimulus at a rate of about billion bits per second²⁸ through our dedicated (unimodal) neural networks of our five senses of sight (iconic), sound (echoic), smell (olfactory), taste (gustatory), and touch (haptic).^{29 30 31 32}

The vast majority of those signals are devoted to subconscious regulation of essential body functions such as breathing, heart rate, sleep, and digestion.^{33 34 35 36} About eighty percent are sight (iconic) and ten percent are sound (echoic). The other ten percent are distributed between olfactory, gustatory, and haptic.³⁷

{Short-Term Memory}

Within milliseconds^{38 39} those signals either decay or are passed along to short-term and working memory where they might be retained for 15 to 30 seconds while being evaluated and categorized for use in cognitive tasks such as learning, reasoning, comprehension, and decision making.^{40 41 42 43} In both short-term and working memory all the sensory signals are processed in a blended (supramodal) manner ^{44 45 46} at a rate of just 10 bits per second.^{47 48 49 50}

{Rehearsal}

Retention in short-term and working memory can be extended through “rehearsal” (also called “maintenance rehearsal” and “rote rehearsal”) by recurrent repetition.^{51 52 53 54}

{Long Term Memory - Memory Consolidation}

Some of that information is encoded into long-term memory through a process termed system consolidation. Somewhat akin to an archive, these memories have a more stable form that is resistant to decay.^{55 56 57 58 59 60}

{Sixth Language Driver}

Our most distant ancestors used their ability to communicate their memories of opportunities and threats with others through commonly understood signals as a tool in their brutal and uncertain struggle for survival.

{National Languages}

We associate languages with a nation or region, which tend to be the language used in the national capitol area. Standard English originated from medieval dialects spoken in the political and commercially dominant London area. The French national language was derived from a dialect of the Paris region, and the Russian national language evolved from the Slavic dialect used in the Grand Duchy of Moscow before it started expanding in the 15th Century.

Here the term will refer to the modalities of spoken, written, and mathematical language.

We seem to effortlessly use spoken, written, and mathematical languages simultaneously when thinking and communicating. In our brains each of these multiple codes (both modality and national) are processed by different combinations of neural networks. It is in our minds that are woven into a single stream of integrated thought.^{61 62}

Experiments have shown that while phonetics (speech sounds) and orthography (spelling) of different language (both modality and national) are encoded and decoded by different sets of neural networks,^{63 64} the semantics and syntax are processed by the mind in an modality-independent manner.^{65 66 67 68 69}

However, because they have unique features and capabilities we are compelled to study each language modality separately.

{dual-process theory}

For example, reading introduces an additional layer of complexity. (Dual-Processing)
("Irrespective of the writing system, reading depends on access to existing brain regions dedicated to the processing of spoken word.")

['The brain signature of emerging reading in two contrasting languages' by Katarzyna Chyl, Bartosz Kossowski, Shuai Wang, Agnieszka Dębska, Magdalena Łuniewska, Artur Marchewka, Marek Wypych, Mark van den Bunt, William Mencl, Kenneth Pugh, and Katarzyna Jednoróg. *NeuroImage*, 225, 117503.]

{Language Definition}

{When Did Spoken Language Appear?}

We cannot currently be confident when spoken language appeared because, as explained by a poet, "words evaporate like water in a dish, leaving you with a sense of something meant, but not the memory of what was said."⁷⁰ Others have simply noted that sounds do not leave fossils.^{71 72}
73 74 75 76

Estimates, based on various clues⁷⁷ including anatomy,^{78 79} control of fire,⁸⁰ carvings on bones,⁸¹ paintings in caves,^{82 84} speculation about cultural transmission,⁸⁵ and presumed religious practices⁸⁶ range from well over a million to merely 50,000 years ago. Independent of when our ancestors first started using spoken language, we are left to question what preceded it and how it evolved.

{Mimetic Communication / Mimesis}

One favored theory is that spoken language evolved from mimetic communication.^{87 88} Mimesis (Greek *mimēsis* = imitation) is a quasi-symbolic communication⁸⁹ that metaphorically expresses meaning⁹⁰ through the intuitive use of imitation, mimicry, facial expressions, posture, gestures, and a variety of vocalizations.^{91 92 93}

{Memory Storage}

Human memory can be stored in the brain of each individual, in the social and collective memory⁹⁴ of those interacting within each information environment, or in the myriad of formats now available that are external to the human mind.^{95 96}

{Cognitive, Linguistic, and Lexical Repertoires}

Memories are the components of the unique and constantly changing cognitive, linguistic, and lexical repertoires of each person. Those repertoires both enable and constrain our interpretation of information, guiding our ability to communicate and cooperate with others.^{97 98 99 100 101 102 103} Repertoires are constructed by memories created during our exposure to the information environments that we are immersed in and exposed to.

{Information Environments}

Every person is a member of various communities of interest based on common bonds created by a multitude of factors including family, age, neighborhood, language, education, work, spiritual faith, along with cultural and sports activities.^{104 105 106 107 108 109 110 111}

Information environment are held together by the common interests of that community. These include family, community, age, occupation, faith-based, education, culture (music, literature, theatre, etc.), and sports.^{112 113 114 115 116} The infrastructure of these environments include the information assets, their creators, the communication and language modalities, and the people who operate in or interact with them.¹¹⁷

Every community of interest has an information environment that is a dynamic and adaptive ecosystem incorporating the entire universe of information learned, shared, and acted upon by members. The environments encompass all of the language and communication modalities, physical environments, social and culture norms utilized by their members.

They are the facts, data, and social conventions that surround us daily as we move through different contexts of home, work, and social activities that require specific knowledge and skills to successfully navigate life.^{118 119 120 121 122 123 124} by enabling and constraining our interpretation and response to information.^{125 126}

{Information Environments - Subsystems and Components}

As with all complex systems information environments have multiple, interoperable, and mutually dependent operating subsystems and components.^{127 128 129 130 131 132}

{Memory is a Major Subsystems of Every Information Environment}

Memory is an essential subsystem of every information environment, and libraries are a component of many memory subsystems.^{133 134}

{Library as Metaphor}

Libraries have been used as metaphors of an infinite universe of knowledge within a structure of endless rooms that evoke the inexhaustible possibilities of human thought, and as labyrinths that lure us into prisons of enigmas with the futile promise of enlightenment.^{135 136 137 138}

Although librarians argue that the Internet is not a library,^{139 140} millions of people are using it as one.^{141 142}

{Recall Repertoire}

The design of every library must strive to accommodate the unanticipated recall repertoire of every possible user.^{143 144 145 146 147}

Even with the marvelous addition of the ability to use voice and image recognition in an Internet search, written language remains the most common search modality.^{148 149}

{Language- Definition}

Language remains a key to this discussion. One definition of language is “a fuzzy cloud in the space of all possible communication systems, a cloud defined by the intrinsic requirements of communication, the constraints and biases of the human brain.”¹⁵⁰ A more functional definition is that languages have a lexicon (words or vocabulary), semantics (meanings or definitions of the words), and syntax (rules for structuring a message).¹⁵¹

{Sixth Language}

Our new age of digital communication and memory technology is the just the latest in an evolutionary chain of languages that includes speech, writing, and mathematics.^{152 153}

{Studied Separately}

Although our minds are effortlessly able to simultaneously utilize all language modalities, we are compelled to study them separately because each has distinct combinations of capabilities and constraints relating to composition, communication, capture, storage, preservation and recall.^{154 155 156 157} Ironically we are compelled to study each modality in isolation because they have different sets of mechanical and cognitive characteristics which determine the type of information that can be identified, preserved in memory, and shared with others within that language community.^{158 159 160 161 162 163 164}

This means that no single language or communication modality can meet our perhaps infinite information needs.^{165 166}

{Mimetic Communication}

Before spoken language it is believed that our distant ancestors exchanged information through mimetic communication,¹⁶⁷ a quasi-symbolic communication¹⁶⁸ that metaphorically expresses meaning¹⁶⁹ through the intuitive use of imitation, mimicry, facial expressions, posture, gestures, and a variety of vocalizations.^{170 171 172}

Instead of words, meaning is encoded in signs that are multimodal combinations of vocalizations and physical gestures (such as pointing). Each combination constitutes a complete holistic unitary utterance (holophrastic) in which the separate components of these signs lack discrete meanings.^{173 174 175 176 177}

The “vocabulary” of signs would have focused on facilitating cooperation in essential tasks such as foraging, hunting, alloparenting, and protection from predators.^{178 179 180}

For example, someone might have signaled the desire to catch, cook, and eat a fish by displaying the holophrastic signs for spear, fish, fire, and eat in that sequence.^{181 182 183 184 185 186}

{Hunter-Gatherer Lifestyle}

Language provided crucial advantages to our distant ancestors in their brutal and uncertain struggle for survival. They faced threats from predators, the high cost of caring for infants during their extended period of juvenility, and in performing the myriad of cooperative tasks needed to gather essential provisions.

Our most distant ancestors lived in balance with nature as nomadic hunter-gatherers, a cognitively demanding lifestyle. Success required the ability to communicate¹⁸⁷ about the various sources of food, the variations caused by geography and seasons,¹⁸⁸ knowing how to control and use fire,^{189 190 191 192 193 194} manufacture tools,^{195 196} and how to efficiently cooperate in securing and sharing the bounty.

Hunting required the ability to share knowledge of the prey, their preferred grazing, and a mental map of their seasonal availability.^{197 198 199}

{Foraging}

For example, one community was found to exploit nearly 30 species of game animals, more than 60 plants, and a variety of other resources,²⁰⁰ while another utilized more than 170 plants just in their various hunting practices.^{201 202 203}

{Tools}

Tools are memory.^{204 205 206}

It has been suggested that two of the most powerful components of grammar evolved from the skills required to make stone tools. Concatenation and recursion allow us to use a finite set of components to create an infinite number of messages.

{concatenation}

Concatenation (Latin *concatēnātiō* = "chaining together") increases the information complexity and density of a message by "chaining" phrases together in a linear sequence.

All stone tools found from the past 3.3 million years were manufactured through iterations of the same operations, basically selecting and then shaping a stone by striking it with a hammerstone to remove flakes and then repeating it until the stone was properly shaped.^{207 208} It would have been natural to apply this when communicating those tasks and sequences.

A simple example would add meaning to the sentence "Look at that cat" by placing the phrase "sleeping in the window" after it.

{recursion}

{Other Uses of Concatenation and Recursion}

These are also foundational tools in mathematics, computer science,^{209 210 211} and music.^{212 213}

{Alloparenting - Pedagogy}

Another burden was the fact that human infants have extended period of juvenility before they could start contributing to the needs of the community. Other members of the group to participate in raising the young, a practice referred to as alloparenting.^{214 215 216} This burden was turned into an investment by teaching the young the knowledge and skills needed to they would need.^{217 218 219}

{Protection from Predation}

There are reasons to believe that protections from predators was a significant driver for an increase in the size of their groups. It is estimated that up to ten percent fell prey to such as saber-toothed cats and giant crocodiles.^{220 221 222 223 224 225}

{Group Size = Language}

As our Stone Age ancestors used language to improve their hunting and foraging knowledge, learned to manufacture tools for specific tasks, and to control fire, the size of their groups increased to an estimated size of just over 100 members. Fire allowed them to cook, reduce the

risk of predation, and is believed to have encouraged them to create and share stories about their culture, their knowledge, and about the unknown.^{226 227 228}

There is an estimate that average group size increased to more than 100 members.^{229 230}

“One of the central theses of this chapter is that protolanguage is an efficient system for communication about cooperation for future goals.”

[Evolution of Mind, Brain, and Culture.pdf, page 194/5/2]

{Scaffolding}

Cultural transmission of the accumulated knowledge improves as the group size increases, creating a “ratchet effect” of increasing the pool of knowledge, which in turn increased the accumulated cultural knowledge.^{231 232} Over untold generations this enabled the development of technologies that no individual could have invented alone.^{233 234}

This success created a need overcome the limitations on share information inherent in mimetic communication because because mimesis cannot meet the basic information sharing needs²³⁵ of groups larger than 150 members.^{236 237} Thus, where the benefits of mimesis made the emergence of spoken language possible, population growth made it necessary.^{238 239 240}

{Multimodality}

Even in spoken language ambiguity is unavoidable because words, intonation, and body language (facial expression, gestures, and body postures) are used in combination to encode a message.^{241 242 243 244 245 246} that are clarified by mimesis and context. Spoken exchanges also have frequent shifts of subject resulting from interruptions when participants ignore the expectation of turn-taking.^{247 248 249 250} One study found an average of 107 interruptions in every five minutes of conversation.²⁵¹ This aspect is being studied to improve the performance of conversational robots.^{252 253}

{Preservation}

Specific face-to-face spoken information exchanges can only be preserved in the memory of participants.^{254 255}

{Collective Memory}

With spoken language, however, the gist can be melded into collective memory through storytelling and songs that can teach when shared during community rituals.^{256 257 258 259 260}

These include epic stories set in poetry, such as the Iliad and the Odyssey, that have been referred to as tribal encyclopedias that were used to preserve and teach cultural memory.^{261 262 263 264}

{Collective Memory}

“One of the first scholars to talk about a collective present in society was Emile Durkheim. Before the term collective memory was established, Emile Durkheim discussed collective consciousness in his work *The Elementary Forms of Religious Life*. Durkheim asserts that “society is a reality sui generis; it has its own peculiar characteristics” and that you cannot derive “the whole from the part, the complex from the simple” (Durkheim, 1912, p. 29). He is saying that society provides an external structure that defines how people live and conceptualize their reality. Society is something more than the sum of individual ideas and actions; society is the umbrella over everyone.”

[‘Collective memory: history, memory, and community’ by Abigail V. Aldis. (2020). Master's thesis/Doctoral dissertation, University of Texas. University of Texas Repository. <https://repositories.lib.utexas.edu/items/79c4eb75-e0e7-4257-b441-e2807b5010cd>] See page 19/2/2, see also page 252.

[*Elementary forms of the religious life* by Émile Durkheim (1858-1917) : Swain, Joseph Ward, 1891- Published: G. Allen & Unwin, Ltd., London, [1915] See page 29.

{Preservation}

After written language was added to our cognitive and communication tool box about 5,000 years, knowledge could be shared with anyone who understood the language in which it was encoded. Preservation expanded to the durability of the media on which it was recorded.

When writing became available about 5,000 years ago a few of these stories (think Gilgamesh, the Iliad, and the Odyssey) were among the first to be set in the new modality that could be preserved for the durability of the media on which it is recorded.

German Merchant's Notebook

Clay, papyrus, velum

{Pedagogy}

Our distant ancestors are believed to have been nomadic hunter-gatherers, which is a cognitively demanding lifestyle.²⁶⁵ For example, one community was found to exploit nearly 30 species of game animals, more than 60 plants, and a variety of other resources,²⁶⁶ while another utilized more than 170 plants just in their various hunting practices.^{267 268 269}

{Ambiguity of Spoken and Written Language}

One reason for the the unavoidable ambiguity inherent in spoken and written language might be illustrated by how the context of an information exchange disambiguates the semantics of the word “right” when used in the binary logical question of whether something is the correct answer, versus when giving directions. Another would be using the word “value” in a discussion of religion versus a decision over whether to invest in real estate or precious metals.

Multiple factors contribute to the ambiguity of spoken and written languages.^{270 271 272 273}

((“Sachs inferred from these results, and later experimentation has amply confirmed her inference, that the original form of a sentence is rapidly lost to memory, whereas an accurate memory for its meaning is retained.” [*Cultural literacy : what every American needs to know*, by E.D. Hirsch, Jr. ; with an appendix, *What literate Americans know* [by] E.D. Hirsch, Jr., Joseph Kett, James Trefil. Boston : Houghton Mifflin, 1987. See page 37

{Information Definition}

Information underlies all human activities, making any definition of that term dependent on the context in that term is used.^{274 275} The current default definition was introduced in the seminal 1948 paper ‘A Mathematical Theory of Communication’ by Claude Shannon. In the first two paragraphs Shannon explicitly noted that he was focused on the fundamental problem of efficient transmission of a communication signal, and that the meaning (semantics) of a message was irrelevant to the engineering problem.²⁷⁶

Shannon developed this definition from his cognitive, linguistic, and lexical repertoires within the information environment of communication engineers. While it unleashed the revolutionary advancements achieved in human knowledge, it is not a functional definition of information required by other essential disciplines such as Literature, cognitive science, sociology, and biology.²⁷⁷

In contrast to the considerable ambiguity of semantics and syntax in spoken and written languages,^{278 279 280 281} the language of mathematics is unambiguous.²⁸²

Shannon definition of information is based on the language of mathematics, which is not adequate for spoken and written language that rely on Multivariate Dependencies of ambiguity, abstraction and metaphor to convey information.²⁸³

“We argue that a spectrum, rather than a dichotomy, exists between ‘subjectivity’ and ‘objectivity’ in research data. At one end of the spectrum are the research approaches Van Merriënboer refers to that ‘[ask] people their opinions’ using interviews, while at the other end are research approaches that attempt to purge all external human influence.”

[‘On the value of the 'subjective' in studies of human behavior and cognition’ by Mark Goldszmidt, Saad Chahine, Sayra Cristancho, Chris Watling, and Lorelei Lingard. *Perspect Med Educ*. 2015 Feb;4(1):49-50. doi: 10.1007/s40037-015-0154-3. PMID:

25630583; PMCID: PMC4348234. At: <https://pmc.ncbi.nlm.nih.gov/articles/PMC4348234/>]

[‘Cognition is ... Fundamentally Cultural’ by Andrea Bender and Sieghard Beller. Behav Sci (Basel). 2013 Jan 4;3(1):42-54. doi: 10.3390/bs3010042. PMID: 25379225; PMCID: PMC4217618. At: <https://pmc.ncbi.nlm.nih.gov/articles/PMC4217618/>]

{Cognition and Decoding}

A computer can replicate the E. E. Cummings poem ‘r-p-o-p-h-e-s-s-a-g-r’ that uses typography and jumbled spelling to evoke our efforts to observe the sudden burst of a grasshoppers movements. But where our minds can find amusement by the authors ingenuity, to the computer it is simply another set of calculations.

However, in the context of this discussion about factors that should be considered when designing an information environment, information will be defined as all conceivable observations that can be detected by human senses.²⁸⁴

A computer can replicate the E. E. Cummings poem ‘*r-p-o-p-h-e-s-s-a-g-r*’ that uses typography and jumbled spelling to evoke our efforts to observe the sudden burst of a grasshoppers movements. But where our minds can find amusement by the authors ingenuity, to the computer it is simply another set of calculations. This is aligned with the way that Andrey Nikolaevich Kolmogorov defined information (algorithmic information theory) the length of the shortest possible computer program (or description) that can generate a specific dataset.^{285 286 287}

It quantifies information content as the length of the shortest possible computer program (or description) that can generate a specific dataset

{Semiotics}

It might help to consider this definition from the perspective of semiotics, the interdisciplinary study of how signs and symbols are used to communicate meaning. Language is considered a subset of semiotics.^{288 289}

When biosemioticians discuss memory in bacteria, they are referring to chemical receptors in those one cell organism that can detect and respond to signals by moving away from threats, and moving toward opportunities.^{290 291 292}

Black holes, an example at a massively larger scale, are hyper dense concentrations of matter with gravity so intense that nothing can escape from them. When astro semioticians discuss black hole memory they are referring to the theory that their outer boundary, or event horizon, retains the encoded information and properties of everything that falls into them. ^{293 294 295 296}

While these examples of information are obviously not within the boundaries of human memory, information about them can be detected and interpreted by biosemioticians and astrosemioticians and must therefore be included in what is preserve and made available by libraries.

{Subsystems and Components of Memory}

Memory is an essential subsystem in all information environments. It can be stored in a biological brain, in community memory, and in modalities external to the human mind (books, computers, the Internet, etc.)^{297 298 299 300}

{The Individual Brain}

Brains are physical organs with an estimated 86 billion neurons, special nerve cells that receive, process, and store information when they receive electrochemical signals from our sensory organs. Neurons communicate with each other by transmitting electrical and chemical signals through synapses connectors located in gaps between them. Each neuron cell has between a few synapses to many thousands of synaptic connections, with perhaps more than a trillion in the average brain.^{301 302 303}

Neurons are organized into neural circuits, ensembles of cells defined by their synaptic connections that dynamically adjust to the strength and frequency of electrochemical signals by modifying the strength and durability of syntactic junctions to encode experiences and behaviors. This “syntactic plasticity” underlies our cognitive functions including learning, memory, and decision-making.^{304 305 306 307 308 309 310}

{Sensory Registers}

Memories are created through a process that begins with ingestion of stimulus through dedicated, (unimodal) neural networks for each of our five senses of sight (iconic), sound (echoic), smell (olfactory), taste (gustatory), and touch (haptic)^{311 312 313 314} at a rate of about billion bits per second.³¹⁵ The vast majority of sensory intake is devoted to subconscious regulation of necessary body functions such as breathing, heart rate, sleep, and digestion.^{316 317 318} While none of our senses operate in isolation,³¹⁹ about 80% of those signals are iconic and 10% are echoic, with the last 10% distributed between olfactory, gustatory, and haptic.³²⁰

{Short-Term Memory}

Within milliseconds^{321 322} those signals either decay or are passed along to short-term and working memory where they might be retained for 15 to 30 seconds while being evaluated and categorized for use in cognitive tasks such as learning, reasoning, comprehension, and decision making.^{323 324 325 326} In both short-term and working memory all the sensory signals are processed in a blended (supramodal) manner ^{327 328 329} at a rate of just 10 bits per second.^{330 331 332 333}

{Long Term Memory - Memory Consolidation}

Some of that information is encoded into long-term memory through a process termed system consolidation. Somewhat akin to an archive, these memories have a more stable form that is resistant to decay.^{334 335 336 337 338 339}

{Memory and Retrieval Cues}

The encoding process also stores “retrieval cues” that assist in recalling information when it might be useful.³⁴⁰

The memory encoding process also stores “retrieval cues” that assist in recalling information when it might be useful. This phenomena applies to a remarkably wide range of factors, including the when and where, other people who were present, and other situational details such as appearance, smell, and colors.^{341 342}

{The Doorway Effect}

The power of cues for recall can be observed in the common “doorway effect”³⁴³ - forgetting why we have walked into a room until returning to where we started and observing the cues. This is due to context-dependent memory, leaving a space where the cues are observable. Perhaps we remember we went to get scissors after seeing gift wrap spread on a table, or that we wanted to retrieve a tape measure after seeing an open catalogue for carpet.^{344 345 346}

Cues might also be why remember the meaning of a sentence much better than we remember the specific words in that sentence.^{347 348}

{Memories and Language}

We can perceive information and create memories without language, but without memories language would be impossible.^{349 350 351}

Our linguistic and lexical repertoires shape the memories that we store, and our interpretation of them. If our language community does not have a word capable of conveying a our interpretation of a memory we cannot share it with others in our information environment.^{352 353 354 355}

For example, near the equator some languages do not have a specific word for snow,^{356 357} and some language communities that do not utilize mathematics lack words for numbers.^{358 359}

In Quechua, an Inca language in the Andes region of South America, the enclitic “*mi*” indicates the information was witnessed, where *chá* means that they heard it secondhand. The is used to judge the veracity of a statement.^{360 361 362}

{Ambiguity in Spoken and Written Language}

{Memory Minders - Poetry}

Just as beer was a way to preserve food before refrigeration, poetry and song were used to retain information by encoding information using rhyme, meter, alliteration, and predictable phrasing.^{363 364 365 366} In the modality of spoken language contrast to our expectation about remembering the exact words in literary text, poetry and song modalities fix the gist of the story instead of requiring fidelity in words and punctuation.^{367 368 369}

{Decoding}

This speaks to the power of collective memory before writing was available (about 5,000 years ago) when stories were how our ancestors captured, preserved, and taught their cultural knowledge and beliefs through entertainment and rituals.³⁷⁰

- ¹ ‘Impact of digital evolution on various facets of computer science and information technology’ by Rajesh Kumar Mishra and Rekha Agarwal. Pages 17-57 in *Digital Evolution: Advances in Computer Science and Information Technology*, edited by Prabhat, S. Prayla Shyry, Saptarshi Paul, and K Chenna Reddy. Bhumi Publishing, India.
- ² ‘Modern computing: Vision and challenges’ by Sukhpal Singh Gill, Huaming Wu, Panos Patros, Carlo Ottaviani, Priyansh Arora, Victor Casamayor Pujol, David Haunschild, Ajith Kumar Parlikad, Oktay Cetinkaya, Hanan Lutfiyya, Vlado Stankovski, Ruidong Li, Yuemin Ding, Junaid Qadir, Ajith Abraham, Soumya K. Ghosh, Houbing Herbert Song, Rizos Sakellariou, Omer Rana, Joel J.P.C. Rodrigues, and Rajkumar Buyya. *Telematics and Informatics Reports*, Volume 13, March 2024, 100116.
- ³ *Athenäum* by Friedrich Schlegel (1772–1829). Volume 1, Part 2, Fragment 80 (1798).
- ⁴ ‘Secretary of Defense James Mattis’ by David Lauterborn. *Military Magazine*. December 1, 2016. Accessed February 22, 2026 at: <https://www.historynet.com/interview-with-general-james-mattis/>
- ⁵ *The idea factory : Bell Labs and the great age of American innovation* by Jon Gertner. Penguin Press, New York, 2012. See page 200/1.
- ⁶ *The mirage of continuity : reconfiguring academic information resources for the 21st century*. Brian L. Hawkins and Patricia Battin editors. Council on Library and Information Resources ; Association of American Universities, Washington, D.C., 1998. See page 7/4.
- ⁷ *The mirage of continuity : reconfiguring academic information resources for the 21st century*. Brian L. Hawkins and Patricia Battin editors. Council on Library and Information Resources ; Association of American Universities, Washington, D.C., 1998. See page 7/4.
- ⁸ *Origins of the modern mind : three stages in the evolution of culture and cognition*, by Merlin Donald. Cambridge, Mass. : Harvard University Press, 1991. See pages 2-3.
- ⁹ *The sixth language: learning a living in the Internet age*, by Robert K. Logan. Caldwell, N.J. : Blackburn Press; 2004. See page 19/2/2.
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