

Data and Time: Information Storage and Paradigms of Temporality

Kurt Ralske

School of Visual Arts, MFA Art Criticism and Writing

1. Data is the De-Temporalization of Events

The defining function of information technologies, both ancient and modern, analog and digital, is the storage and retrieval of events. A single record, a datum, is the representation of a single occurrence. An example may be seen in the verses of the Bible that are genealogical lists ("...son of Kenoth, son of Enoth, son of Seth, son of Adam..."¹). Each record clearly corresponds to a discrete event: the birth of a male child.

With information stored digitally, the one-to-one correspondence of datum to event is less clear. Computer operating systems are designed to assist the user by representing digital information in a simpler form. This layer of abstraction serves to obscure the reality that even digital data is, fundamentally, a recording of discrete events in time. For example, a Microsoft Word document, if considered separately from what its contents signify, is merely a record of the sequence of keystrokes the author made to construct it. The Word file itself is not aware of the semantic content of a word it contains (for example, the word "art"); it knows only that at a specific time, the author pressed the keys "a", "r", and "t", in exactly this order.

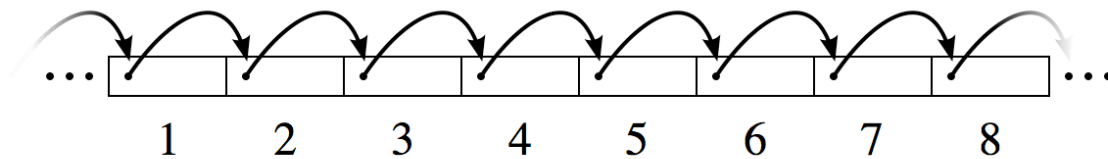
Events in time are recorded and stored as data. When retrieved, the original events are returned to temporality: they come to life, and can thus transmit meaning. A reader of a book mentally reconstructs the actions of the protagonist. A film-goer views still photographs, 24 times a second, and in the mind and eye apprehends actors performing actions, or other sequences of events in time. Through the retrieval of stored events, the viewer enters into a realm of some type of temporality. To record events is to de-temporalize them; to retrieve the stored data is to return events to temporal form.

The topic of this paper is the specific ways in which data is retrieved and subsequently revived into temporality. Data technologies (stone tablets, parchment scrolls, books, magnetic tapes, LP records, computer hard drives, RAM chips) each have a different capability for how data can be retrieved. The central thesis I propose is that a method for retrieving data implies a way of experiencing time; and thus, the most common way in which a culture stores its information influences its consensus paradigm of temporality.

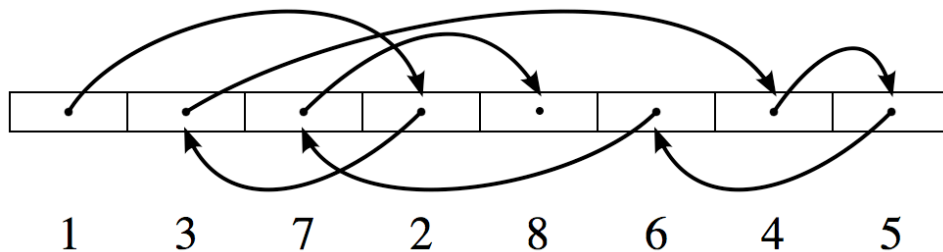
[Note: the term "text" is used in two different senses in this article. The sections that discuss books and scrolls use the "text" to specifically mean "written words". However, generally "text" is used to mean a book, a moving image, a still image, a music composition, or any other container for culturally significant meaning.]

2. Sequential Access and Random Access: The Scroll and the Book

Sequential access



Random access



Two terms, coined by computer scientists in the 1950s², may be usefully applied to all storage technologies, even primitive ones. Stored information may be retrieved either through *sequential access* or *random access*. In sequential access, data is stored as

if in a straight line. The only part of a document that may be retrieved is the bit directly adjacent to the current location. One can access the next bit of data, but not anything in a distant part of the document. To retrieve a bit two positions away, one must move through the intermediate bit first. However, in random access, all data contained within the document is equally accessible. One can randomly select any part of the document with equal ease.

A scroll (such as the ancient Egyptian Book of the Dead, or a Torah) may only be accessed sequentially. One page at a time is exposed. Rolling both sides of the scroll exposes the next page. To skip from a passage near the beginning to a passage near the end is possible only by unrolling and exposing every section in between. A book, on the other hand, offers random access: it can be opened to any page at will. Suppose, for some reason, one needed to check only the first word of every chapter of a text. This would be simple with a book, accomplished with a few page flips. With a scroll, the same task would be tremendously cumbersome, requiring arduous rolling and re-rolling.

The limitations of sequential formats present challenges to their use. There exist ancient copies of the Egyptian Book of the Dead with repeated sections: the difficulty of identifying one's relative location within a scroll caused the scribes to become confused, and errors resulted.³

Sequential technologies might be visualized as a one-dimensional container: a single long line or tube, none of its points connected, rigidly permitting progress only forwards or backwards. A randomly accessible container might be visualized as a three-dimensional sphere: the viewer is at the center, with the data is spread over the sphere's surface; every bit of data sits at exactly the same distance from the viewer.

Two points are worth noting about these definitions. Firstly, "sequential" and "random" are descriptive adjectives, not rigid categories; they are degrees of capability, marking two points on a continuum. Storage mediums are never either absolutely sequential or absolutely random: it is simply that a particular format tends to be more efficient at providing one type of access than the other. The book is more efficient at

random access than a scroll, but a computer hard drive is more efficient still. And conversely, while random access is extremely difficult with a scroll, it is, to some degree, still possible.

Secondly, it is an oversimplification to equate sequential access with analog storage formats, and random access with digital formats. All formats are capable of both, with varying degrees of speed and efficiency. For example, digital storage mediums (such as RAM chips) are efficient at random access, and yet are quite commonly utilized for sequential access. The categories "analog" and "digital" are absolute, mutually exclusive, with no overlap. However, "sequential" and "random" are relative terms, and can usefully describe the capabilities of both analog and digital formats.

3. Examples of Various Storage Formats and Their Accessibility

There are many ways of storing information. Each has its own capability for providing sequential or random access, as well as a history of how it has tended to be used.

The oldest storage technology is the tradition of oral literature: epic poems, retained in the memory of poet-performers, are transmitted from generation to generation. This technique preserved Homer's Illiad and Oddysey for centuries, until, in the wake of literacy, they were written down.⁴ Texts stored in human memory are accessed sequentially: the forward flow of the poem's meter is the device that makes it possible for the performer to retrieve the next passage. Random access would not be easy; if the performer was asked to skip ahead five lines, it would probably be necessary for him to silently run through the four lines in between.

Written text is used in a rigidly sequential manner. Its meaning is entirely dependent on a forward reading. A clay tablet, a scroll, and a book are not identical, but in each, text is retrieved sequentially. The "correct" use of a written text is to traverse an unbroken line from first word to last. A book offers the possibility of skipping to a random location, but this is not the primary intended use of the text.

The audio LP record is another sequential technology. The record needle traces a single line, an unbroken spiral that winds around the disc, from beginning to end, ideally without skipping or jumping.

Cinema film is also a sequential technology. In use, it is like a scroll: a single frame is exposed, and rolling both reels advances to expose the next frame. The film stock is a single continuous strip of celluloid, used by viewing the first frame through to the last. Jumping to a distant point within the film is impossible.

The same is true for all tape-based storage technologies: these include audio formats such as cassette, reel-to-reel, and 8-track tapes; analog video formats such as VHS and Beta tapes; and data tape storage devices, used with home computers until the early 1980s. These are all magnetic storage devices, limited to sequential access by their scroll-like physical structure.

However, computers derive their power from random access, as provided by digital storage devices such as hard drives and RAM chips. ("RAM" stands for "random access memory".) The quality of a user's experience with a computer is determined by how efficiently random access is provided.

There is a small but significant difference between the computer hard drive and the RAM chip. When a hard drive retrieves data, the disk controller moves a read/write head, positioning it at the specific physical location where the desired data resides on a magnetized plate. If the next desired bit of data is not adjacent, the read/write head must be moved to a new location. To retrieve adjacent data is fast; to retrieve (physically) distant data may be many thousands of times slower. With disk drives, the efficiency of access is still limited by materials and by location.

This is not true for computer RAM chips. Here data is stored as positive or negative electrical charges. The process of retrieving them is entirely electrical. There are no moving parts in RAM; there is only the organized flow of electricity. The process of information retrieval is entirely dematerialized, unbounded by physicality. Because all

bits may be accessed in billionths of a second, data is essentially without location. This is the purest form of random access storage.

An example of a use of data that is heavily dependent on random access is video games. The stored "text" of a video game is archive of models, patterns, and actions used for constructing images of objects, locations, and characters. There is no predetermined sequence of events; all events occur in response to the player's wishes. Stored data is selected and reassembled instantly to provide the images and events the player requests.

Similarly, software programs for digitally editing video, still images, or audio files are heavily reliant on the capabilities of randomly reordering and repeating existing material. Programs like Final Cut Pro, Photoshop, or ProTools are used to quickly restructure existing data. Programs for DJ or VJ performance, such as Traktor Pro or Arkaos, provide even faster capability for restructuring sound and image data: they aim to make the process of random access as direct and intuitive as possible, akin to a fine musician's expressive facility with a musical instrument.

CDs and DVDs are also digital storage devices, but they are designed exclusively for sequential access. Like an LP, they dispense the rigidly linear playback of a text (a movie, or a piece of music) from beginning to end. Random access is difficult: think of the delay in skipping to a new chapter of a DVD. The digital DVD is a more advanced technology than an analog audio LP; yet, while an LP may be played backwards, it is impossible to play a DVD backwards.

Broadcast television is a sequential text. One can change channels, but cannot change which part (beginning, middle, or end) of a program one is viewing. However, a digital video recorder such as a TiVo allows the viewer to have some degree of random access to the same material: programs may be paused, and sections may be repeated or skipped.

Digital video files (stored on a computer hard drive) are an unusual case: the way they may be accessed is determined by their compression format (that is, by the particular method used make the file smaller). Some compression formats (such as Photo-JPEG or

DVCPRO) allow random access, while others (such as H.264 or MPEG-2) rigidly insist on being played sequentially. When watching a video file play on a computer, it is not visibly evident if random access is available or not.

Still images are another complex case. Vilem Flusser suggests that information is retrieved from a still image in both ways: randomly, following the viewer's interest, and sequentially, as guided by the composition of the image itself. "If one wishes to deepen the significance [of an image]...one has to allow one's gaze to wander over the surface feeling the way as it goes...one's gaze follows a complex path formed, on the one hand, by the structure of the image and, on the other, by the observer's intentions."⁵

4. Extending Access

Storage technologies are created with a specific mode of use in mind. At times, artists and other innovators have expanded the utility of a storage device by accessing information in novel ways, extending beyond the possibilities foreseen by the designers of the device. New artistic forms result, as well as an implicit critique of the limitations of the old forms.

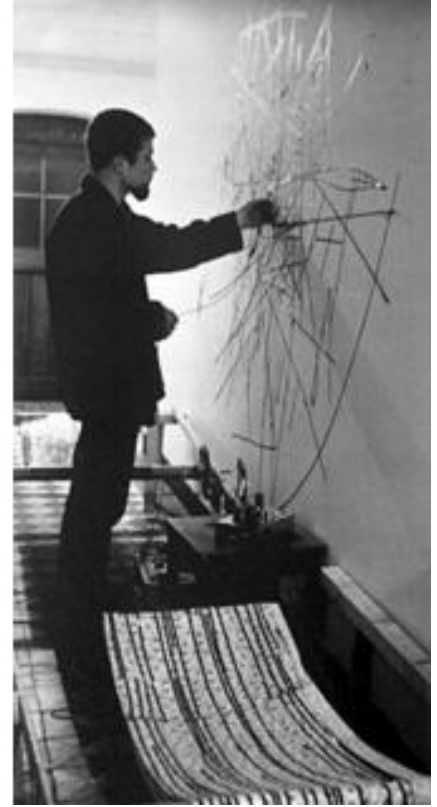
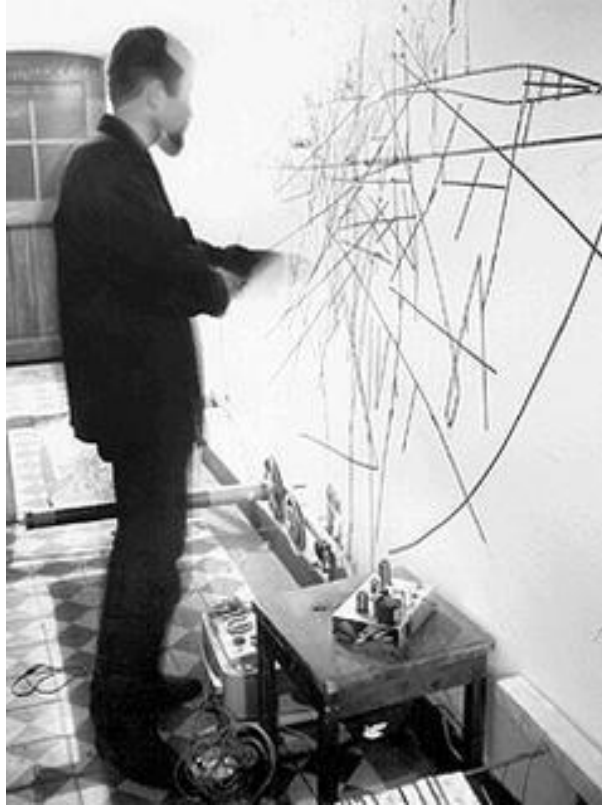
Traditional text storage devices (scrolls and books) are intended for sequential use only. Perhaps the first to break this limitation was Dada anti-artist Tristan Tzara, who in the early 1920s gave a poetry reading by pulling words out of a hat.⁶ (It is not clear from descriptions of the event if the words were cut out from a page - that is, randomly accessed from a pre-existing text - or if Tzara wrote the words himself onto individual scraps of paper.) In the 1950s, Brion Gysin and William Burroughs experimented with the cut-up technique: pages of text were cut into sections and randomly rearranged. They believed breaking the text's sequentiality caused not a loss, but an expansion of meaning. Burroughs considered the cut-up as a form of divination: "When you cut into the present, the future leaks out."⁷

Another strategy was employed by Argentine author Julio Cortázar in his 1963 novel *Hopscotch*. The 155 short sections of the book are intended to be used in two ways:

they are to be read sequentially, as in a normal book, or in a specific random, non-sequential order provided by the author ("...5 - 81 - 74 - 6...").⁸ Cortázar exploited the latent random access capabilities of the book format, extending beyond the rigid convention of the single unbroken line extending from first word to last.

A 1963 sound art installation by Korean artist Nam June Paik, entitled *Random Access*, is especially relevant here. Paik cut sections of magnetic audio tape and glued them to a wall in an irregular pattern.⁹ The viewer is given a playhead, removed from a tape recorder and attached to a speaker. By moving the playhead over sections of the tape, the viewer plays back the original sounds on the tape, but now has total control over the playback: she controls which sections to play, the speed, the volume, the direction of playback (forwards or backwards), and can repeat sections at will. Paik's work allows the viewer to create their own composition by reassembling the source material, and thereby demonstrates the power of utilizing random access.

The audio disc recording, first sold commercially in 1894, is another format designed exclusively for sequential use. The record stylus traces an unbroken line over the single groove that spirals from edge to center, from start to finish. However, in the late 1970s, the technique of record scratching was invented by early hip-hop DJs in New York, such as Grand Wizard Theodore, Grandmaster Flash, and DJ Kool Herc.¹⁰ By manipulating the speed and direction of the turntable, together with the location and pressure of the stylus, the spiral groove of the LP record becomes randomly accessible. Utilizing a variety of motions across the vinyl surface ("cutting", "scribbling", "tearing", "flaring"), the DJ freely and expressively reassembles the source material into his own unique composition.



Nam June Paik: *Random Access* (1963)

5. The Significance of Randomness and Sequentiality

The way in which information is retrieved has an effect on the way it is used. Precisely how do random or sequential access inflect the formation of meaning?

Sequential texts are monolithic. They do not change. They are indivisible: they are meant to be used in their entirety, from start to finish. They exist in one version, the "authoritative" version. Sequential texts thus have a connection with authority or power. Laws and regulations, the expressions of power, retain their validity because they are constant, absolute, unprovisional. Like sequential texts, they do not vary over time and do not exist in multiple versions. The image of the Ten Commandments of Moses, carved on stone tablets, suggests the connection between authority and the constancy of the text.

Conversely, random texts are unpredictable. They are inherently mutable: sections may be reordered at will, repeated, or bypassed altogether. They invite idiosyncratic

usage, customized to the user's wishes. Random texts thus have a connection with individualism and creativity. Personal desires are changing, unpredictable, and unique. Random texts can accommodate them, because any of a near-infinite variety of orderings of the data are equally possible. The internet, our largest and most complex random text, is designed for responsiveness to personal whims: the user accesses information from it in a different pattern each time she uses it.

Random texts also have a link with a particular approach to knowledge. Consider a single text presented in two different formats: in the form of a scroll, and as a book. As a scroll, each section of the text is only a part of a continuous flow from beginning to end. The book, however, offers one important advantage: non-adjacent sections of the text can be compared, merely by flipping forwards or backwards to a different page. The book's greater degree of access encourages a deeper inquiry: at will, the reader reads, re-reads and reinterprets, compares distant sections of the text, makes unexpected connections, or discovers internal inconsistencies. Thus there is a connection between random texts and critical thought: random access fosters an idiosyncratic, personalized usage of a text, thereby allowing individuals to ask questions that amplify, refine, or contradict the meaning within the text.

6. Defining the Varieties of Temporality

All individuals have a concept of time, and a modality for experiencing it. These mental models of time vary between cultures and over historical periods. Two paradigms of temporality are roughly sketched here.

Linear time moves in one direction only: forwards. It is a single unbroken line, extending from past to future. Its motion is rigid and unvarying; it is impossible to skip, return, move backwards, or stop where one is. It is objective, supported by consensus; or more accurately, it is centrally determined and imposed on all. (Consider the standard of Greenwich Mean Time, the U.S. federal legislation that mandates daylight savings time, and Pope Gregory III's 1582 decree of the Gregorian calendar.¹¹) Thus linear time is related to authority and power: it is a standardized format that emanates from a single

locus of authority. It is promoted universally, because allowing dissenting views would lead to inefficiency. (Mussolini "made the trains run on time."¹²) Because the defining quality of linear time is its incessant forward progress, it is akin to capitalist ideals of progress held by industrial cultures: time moves ever onwards, and economic expansion continues ever upwards. We are carried forward by time, and by the forces of the marketplace, whether we like it or not.

Non-linear time, or magical time, does not have a pattern. The defining quality of magical thought is the belief that personal volition can be stronger than causality. Thus the temporality associated with magical thought is controlled by the believer's will: time flows forwards, backwards, returns, or stops, as is desired. It is similar to our relation to our own personal memory: we can recall various events from our personal history, and re-experience them out-of-sequence. The temporal sense connected to magical thought is experienced by children, schizophrenics, and those who choose to structure their beliefs without empirical support. It has also been connected to the condition of post-modern culture, as described by Deleuze, Guattari, Baudrillard, and Fukuyama: the technologically advanced cultures of late capitalism exist in a post-historical state, where linearity is no longer applicable.

7. Data Access and Temporality

Sequential texts correspond to linear temporality. Sequential reading mirrors linear time in its constant forward motion. To read a text is to return stored events to some kind of temporality. The reader experiences the revived actions as mental or sensory events. In following the text's sequential progress from start to finish, the reader is subject to a rigidly deterministic sequence of events or experiences. A member of the audience in a cinema, viewing a Hollywood blockbuster, experiences a 90 minute sequence of sensation whose progress cannot be slowed, halted, or repeated.

In a crowded cinema, the revivification of the text becomes a communal experience. Each member of the audience will interpret the text differently, but all will experience the same sensations at exactly the same time. This illustrates the correlation of

sequential texts and the community, rather than the individual. It also points at the monolithic, authoritative qualities of the sequential text, and of linear temporality: the text, as well as its corresponding temporal modality, emanates from a single source: in this case, the director of the film (who, like everyone, has a commercial and political agenda.) As Greenwich Mean Time provides a centrally determined measurement for standardizing time, the director's sequential text provides a standardized framework for meaningful experiences (at least for the film's duration, if not longer.)

While the text, the movie, may contain within itself temporal dislocations (flashbacks or flashforwards), the reading of text progresses in a rigidly linear manner. The text's narrative may jump back in time, but the cinema-goer cannot ask the projectionist to play a previously screened film reel.

Random texts correspond to non-linear or magical time. As sequential texts produce a rigidly deterministic sequence of sensory events, random texts may be revived into a pattern of events that is controlled only by the reader's desires. The decisions made by the reader create a customized, unique pattern of progress through the text, and thereby time is put under the reader's will. The player of a video game can repeat parts of the text that are especially appealing, skip over less favored sections of the text, or temporarily pause progress, as is desired, creating a personalized sequence of experiences. A digital file of a Hollywood blockbuster, when placed in software for video editing or VJ-ing, may similarly be reordered, repeated, or restructured. The randomly-accessed movie becomes a very different artifact from the sequential text projected in the crowded cinema: it has lost its authoritative, unmutable status, and it no longer unifies a crowd. It has become a unique private experience. Through this experience, engendered by the random revivification of the text, the user amplifies, refines, or contradicts the original meaning of the sequential text.

8. Data Access and Power

It would be oversimplification to assume that random access, with its connections with creativity, individuality, anti-authoritarianism, and critical thought, somehow contains within it utopian possibilities. The situation is far more complex, and worthy of examination.

Just because random access is *possible* does not mean it is *available*. Commercial and political organizations impose limitations on how texts are used, in order to protect their interests. One example is the "Great Firewall of China", used by the Chinese government to restrict their citizens' free access to information on the internet. Another is the battle over issues of copyright, fair use, and piracy, which is, in part, a battle over access. Media corporations are invested in retaining their texts in sequential form (DVDs, broadcast media, pay-per-view). This is the only way they can retain control over them, because random texts can replicate and mutate. It is not digital media that scares these corporations; it is specifically random access that is the problem for them.

Random texts do clearly privilege individual use rather than communal use. This can sound appealing: personal desire is given an outlet and a higher status; dogmatic texts, expressions of authority, become the raw materials for new, individualistic creations. However, this capability for customization becomes problematic when taken to its extreme. Random texts may take on infinite possible forms, modified as each reader sees fit. If all texts exist only in unique, idiosyncratic forms, there is no possibility of shared meaning. Significance arises out of consensus. If there is no version of the text that the community considers to be a standard, there is no way for its meaning to be anything other than idiosyncratic meaning, which is to say, something that cannot be communicated. This impossibility of a "private language" was considered by Ludwig Wittgenstein.¹³

Random texts also privilege the reader's desires. The use of the text, and its revived experience, is under the reader's will. This too sounds appealing, but may again be problematic. The exercise of personal desire would seem to be opposed to submission to authority. However, there is the possibility the opportunity to indulge desire on a small scale facilitates loss of agency on a larger scale. This is similar to what Herbert Marcuse

termed "repressive desublimation"¹⁴: the liberation of desire is enlisted to reinforce the existing social order, rather than challenging or restructuring it. A player of the shoot-em-up video game *America's Army* is master of his own fate, while inside the game: he controls his actions, his progress, even his own life and death. However, the situation is certainly different in the player's life outside the game. *America's Army* was created by the US Army as "a global public relations initiative to help with recruitment".¹⁵ Inside the game, the player is the master; outside, he is a pawn. Indeed, it is exactly the moment when he feels the greatest sense of mastery that he is the most controlled by larger forces. Random texts are not exempted from being used as vehicles for the transmission of ideology. While sequential texts are especially suited to the transmission of dogma because they are standardized, random texts might have a different and equally repressive capability: they may be especially suited to teaching behaviors (instead of beliefs), because they provide a personalized experience, customized to the reader's skills and inclinations. A rote memorization of the American Pledge of Allegiance could justify the idea of killing for one's country, but *America's Army* provides a personalized program of experiences that train one in exactly how it should be done.

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6. Annabelle Melzer, *Dada and Surrealist Performance*, (London: Johns Hopkins UP, 1994), 57.
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