Time machines

Stephen Boyd Davis

Computing mechanizes knowledge. For some people this continues to be controversial. In recent years, some of this controversy has centered on the Digital Humanities, though attempts to defend the human in historiography go back further (e.g. Bridenbaugh 1963: 326 on the 'dehumanizing methods of social sciences'). There is a fear of 'an age where new electronic resources make it possible to do literary research without reading at all' (Culler 2010: 24) or in which 'digitization leads to the decline of the sacred' (Marche 2012). The purpose of this chapter is not to prolong that debate, but to cast it in a historical perspective by looking back to an earlier mechanization of knowledge in the form of uniform, arithmetic representations of historical time. Principally from the eighteenth century, these diagrams predate mechanized computing by almost a century, but are driven, I argue, by a similar enthusiasm for the mechanical – reflected in the concepts of automated cognition and mechanistic knowledge structures, set in a broader mechanical culture – perhaps the first emergence of a machine aesthetic.

When computational machinery was introduced in the mid-nineteenth century, an important dichotomy immediately emerged between mechanical approaches to repetitive work and mechanical approaches to humanistic endeavors, casting light forward to the debates of our own time and backward to attitudes to mechanism in the previous century. When Babbage made his famous remark that astronomical tables should be calculated by steam (Swade 2001: 9) he was invoking the mechanical as a way of eliminating human weakness in ability and performance, maximizing reliable production. This is the mechanical in its most obvious form, where the application of industrial mechanisms such as textile machinery, previously devoted to alleviating or improving the work of the hand, is reapplied to the work of the mind. The *Difference Engine* does useful work, minimizing human toil and avoiding the errors that bedevil some kinds of human performance. Yet as Schaffer (1996: 58) recounts, there was quite another side to Babbage's concept of the machine. Babbage owned an automaton dancer that he put on a glass pedestal in his Marylebone salon in the room next to the unfinished portion of the *Difference Engine*. He also owned a silk portrait of Jacquard, the inventor of the punched-card system for programming looms, woven on just such a loom (Hyman 1985: 181). Babbage used these items to demonstrate to his guests the subtlety and apparently humanistic qualities achievable with an automatic, mechanical system. As Ada Lovelace realized, his *Analytical Engine,* far exceeding the capabilities of its predecessor, was not merely capable of useful work: such a mechanical system might compose elaborate music (Fuegi and Francis 2003). And when the *Analytical Engine* 'weaves algebraical patterns just as the Jacquard-loom weaves flowers and leaves' (Menabrea and Lovelace 1842), this is mathematics considered as philosophical inquiry not just as functional work. This 'other history' of mechanization is important when we consider the relationship between historiography and mechanism.

Chronographics and the timeline

The history of chronographics – visualizations of chronology – has tended to escape serious study: an early exception was Twyman's work at Reading (Twyman 1986, 1990). However, there are signs of increased critical engagement with these significant cultural forms: Rosenberg and Grafton (2010) is the standard work on the history of 'cartographies of time', while Rosenberg (2007) is essential on the chronographic work of Joseph Priestley, an important figure discussed below. A salient word in such studies is 'timeline'. The earliest relevant citation in the Oxford English Dictionary (2011) is from William James' *Principles of Psychology* (1890: 86). Only one component of James' diagram is the 'time-line', rather than the whole design (Figure 1). Nevertheless it shows the key concept of events marked against a regular, uniform 'clock', an idea fundamental to the examples discussed below.

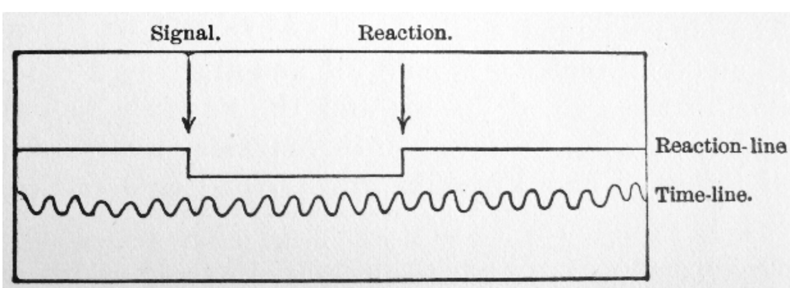

FIGURE 1: An early use of the word timeline (spelled as time-line) in something like its present sense. The waves of the time-line here represent regular time intervals, while the *reaction-line* above it shows a pair of events. From p. 86 of William James' *Principles of Psychology*, vol. 1, 1890, Wellcome Library, London.

Chronology was once a discipline in its own right. Early chronologists, working with lists and tables of events, provided the essential scaffolding of historical time that we now take for granted. Feeney records many instances from classical times (Feeney 2007), while Grafton has traced extensive Renaissance practice, in particular the work of Scaliger (Grafton 1975, 1983, 1985). In the eighteenth century, while 'history' had connotations of perhaps unreliable narrative, chronology offered rigor. It added – various authors argued – meaning, vividness, memorability, an evidential basis and a unifying framework. Locke considered chronology necessary to give history form and meaning (Locke 1693). A landmark in the discipline is Eusebius's *Chronicle* of *c.* 300 CE, which synchronized Christian history with that of the Pagans and Jews in a series of parallel columns, allowing parallelism of events to be observed as well as sequence (Feeney 2007: 29). Meanwhile a quite different graphical tradition exploited the metaphorical and pictorial, attempting to give to history an image and character derived from creatures, humans and other natural phenomena, to assign to history a meaningful shape. I will return to this metaphorical impulse at the end of the chapter. Yet a third influence is that of machines in the form of astrolabes and other devices, and their paper equivalents as *volvelles*. These employed cut-out paper components, typically a small movable disc mounted within a larger one, to determine the locations of the heavenly bodies, tides, the timing of Easter and as other analogue calculators (Kanas 2012: 234). They did not generally deal in historic time, but they may have influenced an early eighteenth-century *volvelle* that did, discussed below.

Nicole Oresme, alone in the 1350s, anticipates later quantitative time graphics (Oresme 1428; Clagett 1968). He traces variation in 'qualities' by altering the distance of a drawn arc from a horizontal baseline that represents elapsed time – perhaps the first visible line-as-time, though Oresme himself traces the idea to Aristotle (*Physics* Book 4) (Clagett 1959: 333). It is intriguing that Oresme also anticipated later adoption of the clock as a metaphor of the heavens (Clagett 1970: 223).

In 1609 Helvicus (1581–1617) attempted to use visual space to enhance the reader's grasp of temporal intervals in his tabular chronology, by using an equal number of pages for every century: '*per aequalia Centenariorum et Decadum spacia distributio*)' (Helvicus 1609: *Ad Lectorem*). Like Eusebius and others, he recognized the potential of the other, non-temporal, dimension: 'the Synchronism of Famous Men, renowned either for their Vertues or their Villanies, doth very much promote a sound knowledge in History' (Helvicus 1687: *To the Reader*: iv).

At the opening of the eighteenth century, the *Discus Chronologicus* (1720) of Christoph Weigel (1654–1725) offered a circular diagram with a paper pointer pivoted in the center, marked in equal intervals of historic time, echoing the form of a clock. Weigel emphasized the structural qualities that his *volvelle* brings out – the 'correct year-order and succession' (*richtigen Jahr-ordnung und folge*). Like

Helvicus, he highlighted his ability to show both sequence and synchrony of events: 'one can see in one effortless view which rulers reigned in the same time together' (*man auch dabey in einem anblick onschwer sehen könne, welche zu gleicher Zeit miteinander regieret haben*, Weigel 1720: rubric on chart).

This theme is taken up in a large rectangular chart published in 1750 by Jean-Louis Barbeau de la Bruyère (1710–81), which attempted comprehensively to map historic time against location, capturing all of the known world since the biblical Flood. Barbeau is not explicit about any mechanical inspiration, but it is interesting to compare his design with those of the man whom he assisted, the Abbé Lenglet du Fresnoy (1674–1755) who in 1729, when Barbeau was 19, published the *Méthode pour étudier l'Histoire* (Lenglet 1729a) and *Tables Chronologiques* (Lenglet 1729b). The four folio sheets of Lenglet's *Tables* together comprise a matrix of roughly synchronized columns of kingdoms, a layout that harks back to the many tabular, typographic productions of the past. The widths of Lenglet's columns are more or less arbitrary, dictated only by the amount of information they need to contain, and the vertical intervals are not uniform, simply listing one event after another regardless of the time elapsing between – but Barbeau reworks this design on a more rigorous, arithmetic, basis, true to his own mechanical-sounding terms: 'order and precision' (*ordre & précision*, Barbeau 1750b chart rubric). Barbeau's *Explication* shows a vital difference from Lenglet's *Tables*: measurement. Width shows each regime's territorial extent, and height its duration (*La largeur marque son étendue, & la hauteur sa durée*, Barbeau 1750a:7) so that any part of the chart yields with some accuracy both the geographic and temporal extents of a particular nation (Boyd Davis 2015b).

Three years later, in 1753, historic time was mapped truly arithmetically to space by doctor, botanist and philologist Jacques Barbeu-Dubourg (1709–79), who created a chart 16.5 meters long plotting all history from the Creation to his own time on a uniform timescale (Ferguson 1991). It is accompanied in the author's explanatory leaflet by a significant appearance of *mechanism* as a desirable model.

Mechanizing cognition

Barbeu-Dubourg acknowledges that he has been inspired by Geography, with its maps, globes and other appealing visual aids[1]; he now plans to make Chronology equally beguiling:

> a science of memory so cold, so sterile, so insipid, may become a science entertaining, and so to speak *mechanised* [pour ainsi dire *méchanique*], which speaks to the eyes and to the mind, […] where memorable events so strike the senses,

> organise themselves so effortlessly in the memory, and are imprinted there so strongly, that we learn almost *automatically* [on s'instruit presque *machinalement*], hardly needing to think what we do.
>
> (Barbeu-Dubourg [1753] 2009: 8, emphasis added)

Machinalement like all mechanical terms was an ambivalent concept. On the one hand *machinale* was said of natural movements in which the will plays no role (*se dit des mouvemens naturels où la volonté n'a point de part*, Dictionnaire de l'Académie Française 1762). In this context, thoughtless automatism is foremost. At the same time in English the word *mechanical* had a number of derogatory senses. It could deprecate materialist philosophies: 'meer Mechanical Principles' are compared unfavorably with those of St. Paul (Anon. 1708: 149). An attack on the 3rd Earl of Bute's encouraging scientific interests in the young George III complains of his 'mechanical toys, baubles, and gimcracks' (Almon 1792: 287). Class condescension is evident, especially where, as was traditional, the mechanical arts are contrasted with the liberal. Defoe mocks one who had 'an Inclination of laying aside his mechanical Employment, to translate himself into a Gentleman' (Defoe 1742: 211). Even Franklin could write 'The Arts, which are more or less liberal or mechanical, as they more or less partake of assistance from the operations of the mind' (Franklin 1769: 331), and elsewhere regrets the 'mechanical sort of Enjoyment' experienced by 'People of low Education and mean Understandings' (Franklin 1750: 39).

So much for the mechanical, apparently. But there is implied praise in Hume's view that the mechanical and liberal arts are mutually dependent (Hume 1753: 26), while Hooke saw Wren as admirably combining 'such a mechanical hand, and so philosophical a mind' (Hooke 1665: Preface), and was later himself praised for 'his mechanical inventions' (Albin 1795: 654). The great *Encyclopédie* of Diderot and d'Alembert, inspired by Bacon and Locke, aimed to treat the mechanical and liberal arts with equal respect (Pannabecker 1994). Though Mayr (1986: 125) suggests a growing British aversion at this time to mechanical metaphors and models, a more nuanced impression emerges when these terms are mapped to the motivations of the authors. For freethinkers, dissenters, proto-scientists and atheists 'mechanical' could be a term of admiration, while for conservatives it was generally a term of abuse. McCallam (2014) contrasts the push at this time among French radicals for rational, logically interrelated measures, against the arbitrary units of the *Ancien Régime*.

In Barbeu-Dubourg's argument, the claimed facility to perceive and to remember *presque machinalement*, effortlessly, is clearly a virtue. Lenglet had claimed that his design constituted '*une méthode que je présente autant aux yeux qu'à l'esprit*' (a method that I present as much to the eyes as to the intellect; Lenglet 1729a: 108), while Barbeau had also claimed that his chart enabled the reader *de* *voir d'un coup-d'oeil tous les Siécles passés* (to see at one glance all the Centuries that have passed; Barbeau 1750a 38). Barbeu-Dubourg is the first to connect this to the concepts *méchanique* and *machinalement*, which he promotes somewhat naively. [2]By contrast, the explanations of Joseph Priestley (1733–1804), theologian, dissenter, natural philosopher and radical, are subtle and thoughtful. At one point in his booklet describing his 1765 *Chart of Biography*, he explains that the chart is 'one of the mechanical methods of facilitating the study of that science [ie. history]' (Priestley 1764: 4*n*) – a familiar praise of the mechanical. But another usage is noteworthy: Priestley discusses how the timescale of his *Chart* (like Barbeu-Dubourg's) is linear, using equal space for equal time. He compares his own design favorably with the non-linear design of a recently imported French chart, almost certainly that of Barbeau de la Bruyère discussed above (Barbeau 1750b). Clearly the mechanical in visual perception is a quality that must be handled with care:

> the same scale is made use of through the whole of the chart of Biography [i.e. Priestley's own], whereas several are used in that of History [i.e. Barbeau's]: the consequence of which is that, in comparing intervals of time in different parts of that chart, the imagination is necessarily imposed upon. Even the notice which is given of this change is not sufficient to correct the error of the imagination, which is *impressed mechanically by the view of the spaces* [...] in the chart.
>
> (Priestley 1764: 8, emphasis added)

In other words, something misleadingly designed, once perceived, will be fixed in the memory: what is cognized mechanically cannot be undone by ratiocination. In our own time the visual is often presented as unambiguously beneficial; since that early remark by Priestley the potential of visualization to deceive has been little touched on, though a worthy heir of Priestley in this respect is Tufte (1983; 1997), who repeatedly emphasizes the misleading nature of much visual information.

Mechanical knowledge structures

Barbeu-Dubourg seems in 1753 to have been the first to plot historical time linearly and arithmetically on a uniform scale, while in 1765 Priestley was the first to represent duration using a printed line to represent each life (Twyman 1986): 'They are the lines, in this case, which suggest the ideas, and this they do immediately, without the intervention of words' (Priestley 1764: 9). This eminently mechanical approach to representation takes Priestley some effort to explain, but he suggests that it works because it is natural to think about time as

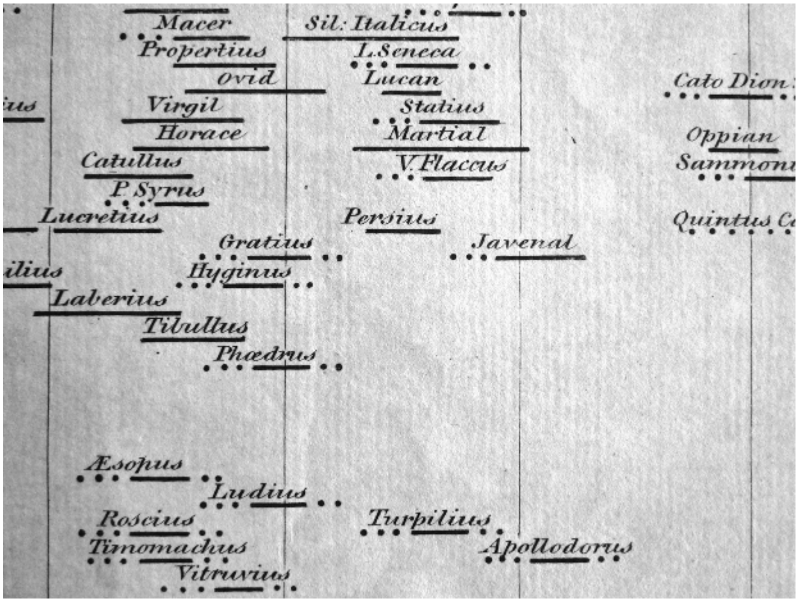

FIGURE 2: Joseph Priestley's 1765 *Chart of Biography* (detail). Clusters and periods with little data are clearly visible in this mechanical mapping of time to space. Photo: Stephen Boyd Davis. With permission Chetham's Library, Manchester.

though it were space (1764: 7). One automatically maps to the other: a certain lifetime produces a line of a corresponding length, as though drawn mechanically (Figure 2). The result has an intriguing resemblance to the later invention of the piano-roll, which of course embodies a reverse relationship, in which a representation drives a machine.

In 1753 Barbeu-Dubourg went so far as to build an actual machine (*une Machine d'un usage facile e commode*) to house and present his historical timeline (Figure 3).

In his 1777 *Harmony of the Evangelists in Greek* (subsequently 1780 in English), Priestley grappled, as many have done, with the problem of deriving one history from the four gospel accounts in the New Testament, and espouses an explicitly mechanical approach. He shares some of Barbeu-Dubourg's over-enthusiasm for rapid and automatic comprehension:

> I venture to say that, by the help of such a *mechanical* contrivance as this, a person of a very moderate capacity, or critical skill, will have an advantage over a person of the greatest genius and comprehension of mind without it.
>
> (Priestley 1780: xvii, emphasis added)

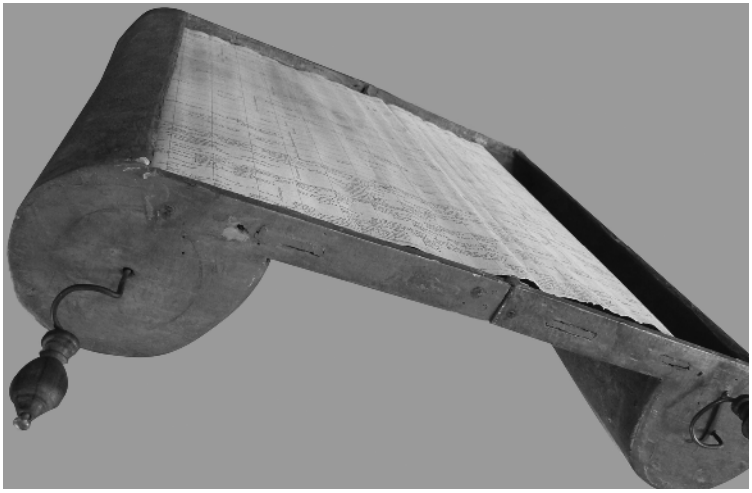

FIGURE 3: J. Barbeu-Dubourg 1753. The *Carte Chronographique* housed in its machine. Photo: Stephen Boyd Davis. Permission of Rare Book Division, Department of Rare Books and Special Collections, Princeton University Library.

This unfortunately echoes all too closely Swift's parodic professor with an *Engine*, who announces to Gulliver that 'the most ignorant person at a reasonable charge, and with a little bodily labour, may write books in philosophy, poetry, politics, law, mathematics, and theology, without the least assistance from genius or study' (Swift 1726: 71). Swift's intolerance of the mechanical is explicit – this is 'a Project for improving speculative Knowledge by practical and mechanical Operations' – cohering with his generally conservative point of view.

Figure 4 shows the result of Priestley's mechanical process. The most striking feature is the visual gaps, the empty spaces, at times resembling the famous empty page in *Tristram Shandy* by Priestley's older contemporary Sterne (1713–68). He describes his approach: 'If I should be thought to have succeeded in this work better than the generality of my predecessors, I shall attribute it chiefly to the *mechanical methods* I made use of' (Priestley 1777: xvi, original emphasis). He goes on to explain how he cut up two copies of the gospels and rearranged them (1777: xvii) to create his design.

Priestley had already noted in his *Description of a Chart of Biography* how empty space has meaning. The empty spaces in the *Chart* reveal to Priestley the disastrous absences in the Dark Ages: 'the thin and void places in the chart are, in fact, not less instructive than the most crowded, in giving us an idea of the great interruptions of science, and the intervals at which it has flourished' (Priestley 1764: 24). A mechanical model of historical time is crucial to revealing these patterns, clusters, drifts and absences. What Poole calls the 'lumpish quality of time' (Poole 1998: 23) of previous centuries, with its uneven succession of periods

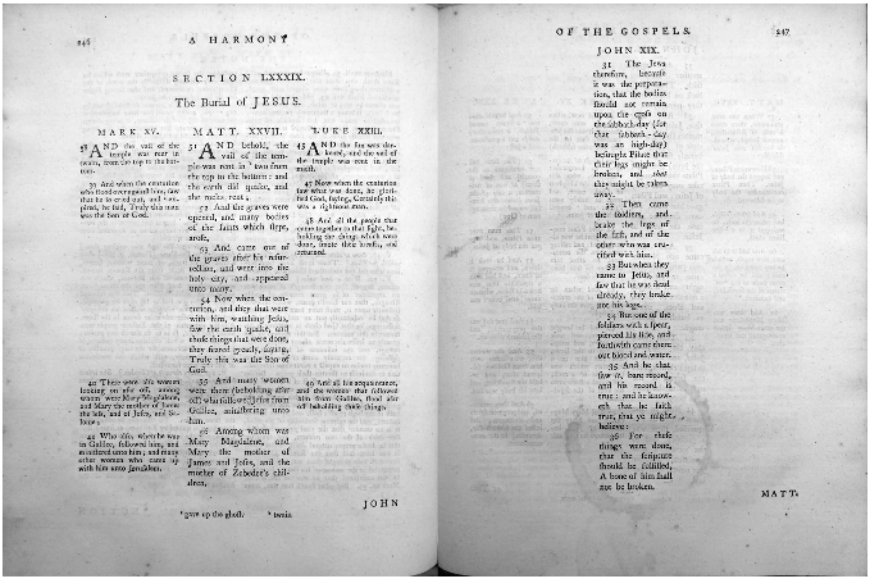

FIGURE 4: Pages 246 and 247 of Priestley's *Harmony of the Evangelists* of 1780. Aligning the four Gospel accounts according to time, using between one and four columns per page. Collection: Stephen Boyd Davis. Photo: Stephen Boyd Davis.

of different qualities, has been replaced by Newtonian time, an absolute, neutral and uniform container for events, whose patterning emerges graphically.

Priestley is linked to Barbeu-Dubourg by a shared friendship with Benjamin Franklin, whose works the Frenchman translated. Mechanical methods for handling knowledge emerge also in a letter from Franklin to Priestley. Writing in response to a request for advice, Franklin, instead of answering the question, outlines his 'moral or prudential algebra' (Franklin 1772). A miniature of Bentham's later felicific calculus, it is a visual method for balancing all the weighted advantages and disadvantages of a course of action on a single sheet of paper until a clear preference emerges. Like Priestley's innovations in diagramming time, it depends on having all the data in view and organized on a surface according to a mechanical system, and emphasizes the automatic emergence of sense. Both the information handling and the resulting cognition are mechanized.

Mechanical culture

Today it may be difficult for us to enthuse about mechanical uniformity, but this was one of the great cultural innovations of the eighteenth century – though admittedly with deep roots, for example in the shift from hours of unequal length to those measurable by clocks (Dohrn-van Rossum 1996: 19) or the aural uniformity introduced by the ticking of Huygens' spring mechanism in the 1670s (Sherman 1996). The eighteenth century was the century of Tull's improved design of seed drill which, though not widely adopted, would have been familiar in 'improving' circles like Priestley's: hand-broadcast seed was replaced by multiple parallel lines of plants. Natural watercourses were mechanized through the canal system, with over 3,100 miles of canal built in Britain between 1760 and 1800 (Lowson 1998). Urban terraces in improved cities like Bath and Edinburgh employed simple repetition and equality of every unit in the façade. Even pavements, until mid-eighteenth century in Britain the responsibility of individual householders and therefore having different heights, materials and quality, began to be replaced by uniform paving funded through local taxation (Cockayne 2007: 202). In terms of measurement, it was in 1758 that a standard Yard measure was first established in Britain (Sawday 2007: 71), while in 1752 Britain's calendar had at last been made consistent with that proposed by Pope Gregory XIII in 1582.

Schaffer shows how the principles of mechanization in this period encompassed such apparently diverse fields as the world of entertainment and the factory system (Schaffer 1999). The year 1759 saw both Van Kempelen's mechanical chess-playing Turk and Arkwright's patents for the spinning frame. At its worst, machine inspiration resulted in proto-Taylorist images like Adam Ferguson's: 'Manufactures, accordingly, prosper most, where the mind is least consulted, and where the workshop may, without any great effort of the imagination, be considered as an engine, the parts of which are men' (Ferguson 1767: 273). Interestingly it was this same Ferguson (1723–1816) who created another early timeline, the first to appear in the *Encyclopaedia Britannica* (2nd edition 1780: plate opposite p. 3689). Perhaps the timeline and the mechanical vision of the workshop are two indicators of a single informing fondness for the machine. One of the students whose thesis examination Barbeu-Dubourg presided over, in February 1768, would later find his name given to a famously mechanical engine of death: Joseph-Ignace Guillotin (Delaunay 1904: 12). Sawday (2007: 97) makes the interesting observation that, for machinery during the Renaissance period, simplicity and efficiency were not important criteria: complexity was welcomed. It is the eighteenth century that sees the emergence of a machine aesthetic as we would recognize it today: the rigor and abstemiousness of the Barbeu-Dubourg and Priestley timelines are a part of this visual culture.

Though Babbage and Lovelace's thinking pointed to the future, their work also had echoes of the automata of Barbeu-Dubourg and Priestley's century, which intrigued by showing subtle behaviors while being mere machines. While perhaps to our eyes projects such as Vaucanson's automaton *Duck* and *Flute Player* appear bathetic, in contemporary accounts what comes across strongly is the desire to make machinery sensitive and subtle. Vaucanson had to acquire new knowledge about how the sounds of a flute are produced, to the extent that his notes are used today by musical scholars studying the flute playing techniques of the period (Lasocki 1979). Subtle investigation and transformation were essential to his working method, not 'mere' mechanization.

The application of mechanical uniformity to chronography created new problems of its own, including the alarming extent of nearly blank paper. Because of the long timescale of Barbeu-Dubourg's chart (he starts with the Creation in 4700 BCE while Priestley starts at 1200 BCE), his readers are presented with a large area of nothing very much: there are almost no persons or events in the first eight sheets of his long timeline. The new format could not accommodate the fact that there is almost always more data available for recent times than for the distant past, and that this would seem to require some kind of non-linear 'perspective', where the nearest time is assigned more space. Such a perspective was indeed adopted by Barbeau de la Bruyère, of which Priestley was so critical.

Mechanical approaches in question

The mechanical approach to chronographics, new in the eighteenth century, led to the emergence of quantitative graphics such as Playfair's 'lineal arithmetic' in the form of line graphs and bar charts in the 1780s (Costigan-Eaves and Macdonald-Ross 1990: 325), mechanical diagrams devoid of figurative visual metaphor. Twyman (1990) notes how this emergence of modern information graphics in the late eighteenth century, including Lambert in Germany in the 1760s and 1770s and Playfair in the 1780s, is an important cultural shift 'yet to be satisfactorily explained'. It is also important to note that the ancient figurative-metaphorical tradition was by no means overwhelmed by this emergence of the arithmetic-mechanical. The very neutrality of mechanical approaches seemed to some to diminish their ability to 'tell a story'. Though the clustering through time, combined with the grouping into countries and categories common in such visualizations, has evident explanatory power, it seemed to some rhetorically inadequate. They abandoned the abstemious mechanical plotting of lifelines to time for richer visual forms. As Rosenberg (2007: 83) highlights, Strass (1766–1845) specifically objected to the flatness and neutrality of Priestley's view, favoring a highly authored, hand-drawn grouping and linking of currents and tributaries in the stream of time (Figure 5).

Similarly, Emma Willard (1787–1870), educator and activist, complained:

> Mere straight lines not wrought into a picture, and presenting no form or comeliness to the eye, are unattractive. The young (and the old too) do not feel any

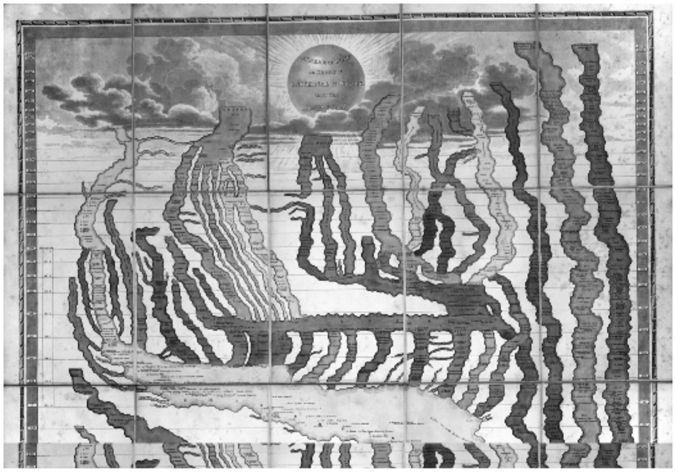

FIGURE 5: W. H. Strass 1849. *Stream of Time, or Chart of Universal History*. London: C. Smith, Mapseller. Detail. The mechanical neutrality of Priestley's chart is replaced by the rhetoric of hand-drawn rivers of time. Collection: Stephen Boyd Davis. Photo: Stephen Boyd Davis.

> wish to look at them, and thus they carry away no distinct impression. They are like a succession of monotonous sounds, which no one remembers; while the arrangement of sounds in tunes, or lines in pictures, are attended to with pleasure, and easily remembered.
>
> (Willard 1849: 12n)

Willard invokes pleasure and memorability as the key advantages of her preferred visual rhetoric. She does not acknowledge that it facilitates her projecting a very particular interpretation of history, to translate her country as a physical entity into the image of a unified nation (Schulten 2007).

Implications

The objection that charts such as Priestley's do not properly represent *history* is echoed still today: 'history is not imaged in the graph, only time. Priestley's chart took time for history' (Maas and Morgan 2002: 102). The application of mechanism or of computing to any task habitually prioritizes those things that are easiest to do, and the automatic distribution of events across a graphical space is no exception. It is easier to chart chronology than to chart history. Little has so far been done to extend visual sense-making to embrace the rhetorical or narrative tradition championed by Strass and Willard. This is an important topic for research.

Yet even within 'simple' chronographics there is much to play for. At their best, they yield knowledge unavailable by other means. Where they are interactive, they can be interrogated to yield new insights. But they must be designed with the complexities, subtleties – the sheer messiness – of history in mind. The growth of Digital Humanities has seen a new interest in historical visualization – some conceiving time as an obvious 'dimension' against which to map artefacts, such as Manovich's *Software Studies Initiative* (Manovich 2010), while others question such use, for example in the *Temporal Modelling* project at Virginia and its successors (Nowviskie 2004; Drucker 2011; Nowviskie et al. 2013). The relative lack of critical debate around temporal mapping is particularly regrettable when contrasted with the richer discourse around cartography and its digital forms, now often discussed under the aegis of Spatial Humanities (Bodenhamer et al. 2010; Gregory and Geddes 2014).

Thoughtful practical attempts at interactive, digital timelines started to emerge in Massachusetts Institute of Technology's *Simile* (Simile 2009), Southampton University's *Continuum* (André et al. 2007) and a long series of deeply considered temporal visualizations (but not applied to history more broadly) at University of Maryland (Plaisant et al. 1996; Wongsuphasawat et al. 2011; Du et al. 2016). Three-dimensional chronographics have been evaluated experimentally, though inconclusively (Korallo et al. 2013). Kräutli has investigated the contribution of critically informed design at the intersection of the humanities and the digital (Boyd Davis and Kräutli 2015). As he points out, crucial to visual historiography is a mature approach to uncertainty. Most of the generic forms of data-uncertainty identified by Pham et al. (2009) affect historical material, including limited accuracy, missing data, incomplete definition, inconsistency, personal bias, ambiguity of description and embedded assumptions. At the United Kingdom National Archives, a recent AHRC-funded project has devised methods of computing the likelihood of two named individuals in fact being the same person – and the answers produced by such a process must be a likelihood, not a binary choice (Bell and Ranade 2015), with complexities that demand suitable graphic representation. Yet because computers deal most easily with certainty, we pretend graphically that our data are sure, precise and uncontested (Boyd Davis et al. 2013). Indeed digital methods often introduce *new* problems such as quantization (Kräutli and Boyd Davis 2013; Boyd Davis and Kräutli 2015: 108).

Though each of these insights and advances is helpful, much remains to be done before we can say we have a digital repertoire worthy of historical research and presentation. Simplistic use of machines produces simplistic representations of knowledge. Perhaps now is the moment for Temporal Humanities, in which the visual representation of historic time would become a substantive, perpetually contentious subject rather than a series of assumptions.

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NOTES

1. See Boyd Davis (2015a) for the adoption of geography and cartography as metaphors for history and chronology. I argue there that this is in itself dependent on historical time being seen as a dimension analogous to those of space.
2. Barbeu-Dubourg seems to have tended toward the naïve. His political essay Petit Code de la Raison Humaine (1773) seems almost childish, though admired by Benjamin Franklin. He lost his small fortune in attempting idealistically to supply arms to the American Revolution, competing unsuccessfully for the role with Beaumarchais, the author of *The Barber of Seville* and *The Marriage of Figaro* (Bass 1970).