Scholarly chronographics: can a timeline be useful in historiography?

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Timelines – visual, spatial presentations of chronology – are generally regarded as being too simple, perhaps too childish, to be worthy of academic attention, yet such chronographics should be capable of supporting sophisticated thinking about history and historiography, especially if they take full advantage of the capabilities of digital technologies.

Time, Chronographics, History, Data Visualisation

1. INTRODUCTION

The mapping of historic time has made only modest intellectual progress since it was invented 250 years ago. Until recently, visual chronologies such as timelines – a class of representation we will refer to as chronographics – have largely escaped serious study. While there is a nascent academic literature and an increasing, if generally naive, body of practice, the lack of theorisation in the visual mapping of time contrasts strongly with that in cartography, the visual mapping of space. There, argument rages over the respective merits of the Mercator, Gall-Peters, and other projections, with a clear understanding that each presents a different world view and that these differences matter (Wood & Krygier 2009). Feminist geography exemplifies the extent to which maps are rightly seen as contingent, contentious and loaded with embedded meanings (Rose 1993; Kwan 2002). The awareness that maps represent particular ideologies, parties and claims has even made its way into populist academic literature through the works of Mark Monmonier (1996; 2008). In terms of practice, geographic maps are highly varied in the range of functions and of users that they serve, and the sophistication with which they represent aspects of the world. They are regarded as powerful tools not simply to present information, but to facilitate inquiry and analysis. This reflexive, interrogatory use is increasingly facilitated by their being digital and intimately interconnected with underlying geographic information (Dorling 1992; Dorling 2013).

Figure 1: Martignoni. 1718. Chart of the Roman Empire. 56cm x 57cm. Collection / photo: Cartographic Institute of Catalonia (Creative Commons BY-NC-ND 3.0)

We suggest that the time is right for chronography to begin to take its place alongside cartography. This raises many questions of how one should think about mapping time. What would it take for maps of time to be as subtle, sophisticated and useful to scholars as maps of the physical world have become? It is the aim of this paper to offer a glimpse of the broad range of issues that require discussion, within which we then highlight one important question, that of scale. This serves as an illustration of the need for a critical discourse around chronographics in general. To set the context, we also offer a brief digest of the history of chronography, showing its emergence from an Enlightenment model of time, and focusing on the aspirations of the early pioneers. We do this not simply from historical curiosity – though the early examples are fascinating and the rationales offered by their authors full of interest – but because the aspirations associated with these early examples offer an important agenda even now.

2. A BRIEF HISTORY OF MAPS OF TIME

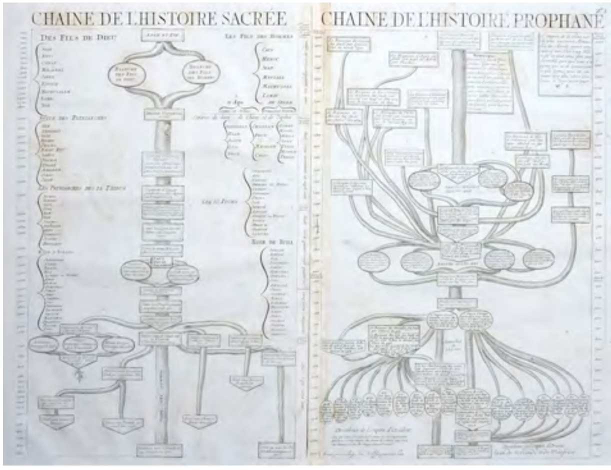

Figure 2: Chatelain. 1721. Atlas Historique. Chart of Sacred and Secular History. Collection / Photo: Stephen Boyd Davis

Perhaps the simplest representation of past time is the list. Events are named, perhaps dated, in sequential order, and may be organised on the page as a row or column. Even now, the word 'timeline' is regularly used to denote such lists, in which events are packed close on one another, and the space occupied by each event is a simple outcome of the size of the label or description. Such lists tell us about order, and not much else. A significant step up is the table or matrix. These make it possible to coordinate multiple lists in time, showing not only sequence but synchrony. The classical roots of such arrangements are traced by Feeney (2007 passim). A landmark is Eusebius's Chronicle of c300CE, which synchronised Christian history with that of the pagans and Jews in a series of parallel columns (op. cit. 29). Such matrices still fail to offer two important pieces of information: the intervals between events and the overall sense of scale. Only by mapping time arithmetically can these two features of history be represented; they appear in the true timelines that emerged in the early to mid 18th century. This transition from lists and tables of time to true timelines can be seen as representing a change in the ontology of historic time itself, from an earlier conceptualisation where history is simply the accretion of events to one in which it is a quasi-spatial dimension or terrain in which events are situated, as advocated by Newton. Priestley, discussed below, specifically calls his design an 'ocular demonstration' of Newtonian time (p14).

Chronology's relation to history today is as a poor relation. The battles to set dates into an agreed sequence have either been settled for most practical purposes, or abandoned. It is ironic that one of the primary motivations for chronological scholarship was the attempt to make sense of the timing of events in religious texts, the very domain which is no longer of interest or concern to most historians. A cusp figure here, as in other fields, is Isaac Newton, at one time seen as a proto-modern scientist, but now known to have admitted spending thirty years grappling with the chronology of ancient kingdoms (Newton's studies have recently been discussed in depth: (Buchwald & Feingold 2012)). Newton's concept of time as 'absolute, true, and mathematical' will be seen to have significantly influenced the emerging timeline.

Among the earliest investigations of past chronographics is Twyman's discussion of the innovations of Joseph Priestley from the 1760s onwards (1986). Those innovations included the popularisation of a linear scale for the time axis, the use of a drawn graphic line to represent the duration of a life, and an argument that the empty spaces in a chart of time are not simple absences but carry meaning. These points are discussed below. Twyman's approach is situated within the fields of graphic design, of information design, and of print technologies. More recently a survey of the history of the timeline by Rosenberg and Grafton (2010) is scholarly, comprehensive, and highly visual. It particularly addresses the historiographical implications of the evolving timeline, and traces a vital strand through visual culture. Rosenberg's extensive article specific to the timelines of Priestley is also a major contribution to the subject (Rosenberg 2007). In our own work we have traced the influence of mechanical models of cognition and organisation on early timelines (Boyd Davis 2010) and more recently the complementary influence of metaphors and techniques of geography and cartography (Boyd Davis 2014).

Chronography emerges from chronology. In the 18th century, while 'history' had connotations of narrative and story, chronology provided rigour. What chronology added to history, various authors argued, was meaning, vividness, memorability, and a unifying framework. Chronology provided the structure and reliability that history lacked.

Locke asserts that chronology allows persons and histories to be set in a sense-making framework 'ranked in their proper places,' without which the past is 'only a jumble of matters of fact, confusedly heaped together'. Without 'that natural order' they are unable to work history's improving effects, to 'afford those observations which make a man the better and the abler for reading them' (Locke 1693, p.217). Even before the emergence of chronography as such, the claims made frequently employ visual metaphors: the eye and light are both repeatedly cited. Limiers (1720), in an essay for Chatelain's seven-volume Atlas Historique, emphasises form and method, suggesting that history provides the material to which chronology gives form and method without which 'it would be an account merely confused and dark' (ne seroit qu'un récit confus & tenebreux). Chesterfield, in a letter of 1739 (Stanhope 1774, p.106) uses the image of eyes: 'Chronology and Geography are called the two eyes of History, because History can never be well understood without them.' Jackson (Jackson 1752 p.xxv) claims that chronology vivifies history: it is as necessary as the soul is to the body: 'without Chronology, History is lifeless, and no better than a dead Body without Sense or Understanding' ... 'Chronology is the Eye...'. Blair (1754[1]) argues the unifying, structuring effect of chronology: 'the Series of Time, according to its proper Periods ... make what is call'd, the Thread of History: without which, it is really nothing more, than a Bundle of Detached Fragments.' Memorability is a key virtue of such a framework. He revisits a standard metaphor for Chronology: 'the Eye of History; because this Metaphor, expresses better than any other, how it opens a Light, upon the most dark, and complicated Revolutions of Mankind.'

Goffart (Goffart 2003, p.105) and Grafton (Grafton 2007, p.92) note the longevity of the eye metaphor, which has two forms. In one variant, chronology is the single eye of history. This is the formula favoured by Ortelius, in the Theatrum Orbis Terrarum (Ortelius 1573) invokes 'Geography, that is rightly called by some the eye of history' (Geographia quæ merito a quibusdam historiæ oculu appellata est). But already in the early seventeenth century, Samuel Purchas (Purchas 1614, p.613) was citing a version – found in Chytræus (1563, p.25) – where Geography and Chronology are the two eyes of History. These visual metaphors, of eyes, light and lamps, create a powerful prelude to the actual visualisations of history that were about to emerge.

2.1. Early claims for visualizations of time

In 1718, Girolamo Andrea Martignoni (died c.1743) published a large engraved chart of history inspired by geographic maps and centred on the Roman Empire (Figure 1), together with a substantial Explication de la Carte Historique de France et de l'Angleterre (Martignoni 1721a) and Spiegazione della Carta Istorica dell'Italia, e di Una Parte della Germania (Martignoni 1721b) containing sample portions of a still larger version of the same chart, apparently never produced in its entirety. His claims include the idea of a visual summary – 'par une nouvelle invention, de faire voir en abrégé dans une Carte, toute l'Histoire principale de l'Empire Romain' (Martignoni 1721a§1). He also claims that he offers multiple forms of access, in that there are three different ways of interrogating his chart: tracing events and successions; following centuries, and tracing the histories of major families. These are facilitated by its being visual.

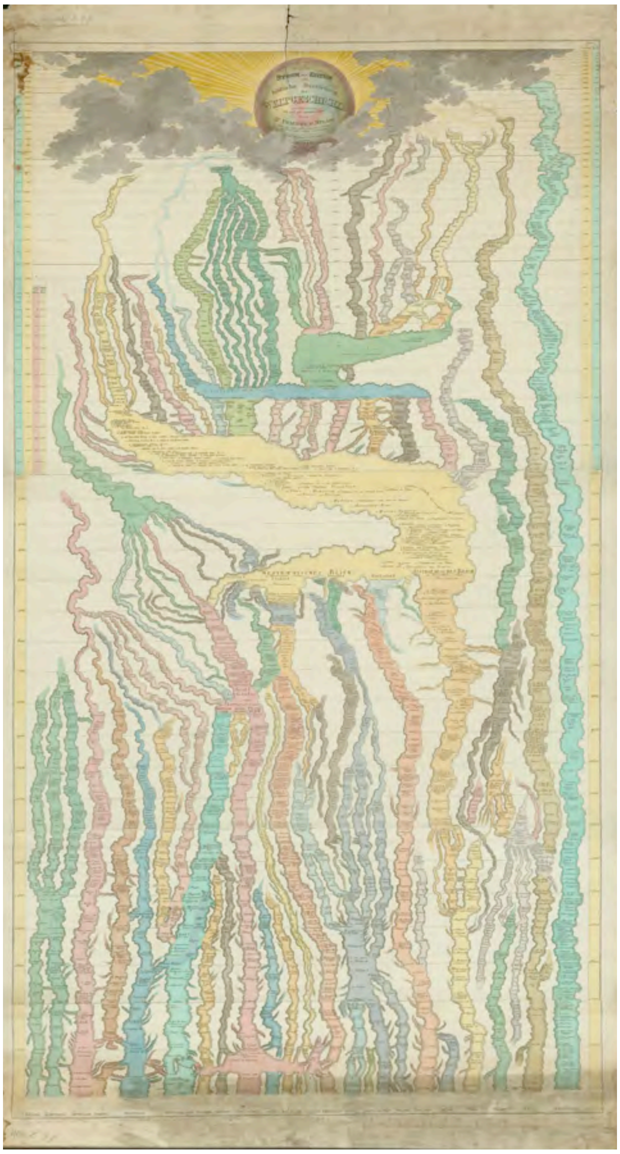

Figure 3 Friedrich Strass' 'Stream of Time' uses the metaphor of a river to show the formation and disappearance of empires through history. Used with permission. Source: http://bildsuche.digitale-sammlungen.de/index.html?c=viewer&bandnummer=bsb00003029&pimage=00001. (c) Bayerische Staatsbibliothek München

Martignoni also claims that the use of his chart is enjoyable, and that is more memorable than text: 'an easy means of learning History, in a manner that pleases the Mind and relieves the Memory' (un moyen facile pour apprendre l'Histoire; d'une maniére qui puisse faire plaisir à l'esprit, & soulager la mémoire) (Martignoni 1721a§1). The notion of visual presentation providing a more enjoyable encounter with history will be seen to recur in later authors and can be regarded as a primary motivation for chronographic invention. The Abbé Nicolas Lenglet du Fresnoy (1674-1755) similarly claims that his more conventional chart – a series of roughly synchronized columns – 'pleases considerably more than it tires' (elle plaît beacoup plus qu'elle ne fatigue) (Fresnoy 1729a). He introduces the implication that his chart bypasses some of the cognitive processes associated with reading: 'this is a method that I present as much to the eyes as to the intellect' (c'est une méthode que je présente autant aux yeux qu'à l'esprit) (op. cit.:108). This notion of more direct access to knowledge through vision will also become a regular claim. More unusual is the Abbé's interest in representing uncertainty. Rather than using his diagram to simplify chronology, he uses it to draw attention to its notorious difficulties. Rather than forcing his dates into a single chronology, he uses the chart to display in parallel columns the key points of difference, such as those between Usher, de Tournemine and Serrarius (Fresnoy 1729b). Few chronographers since have troubled themselves with uncertainty of any kind, succumbing to the temptation to make clean, uncluttered, unequivocal charts, which perhaps explain why timelines are not normally regarded as a serious tool for the historian. We shall however note below a key innovation by Priestley that addresses uncertainty in another form.

Jean-Louis Barbeau de la Bruyère (1710-1781) worked on later, less interesting, editions of the Abbé's chronologies, but also produced his own remarkable diagram, the Mappemonde Historique (Barbeau de la Bruyère 1750b). It was an attempt to represent geography and chronology in a single chart, using the horizontal axis to distribute countries, and the vertical to represent time on a non-linear scale. Like Martignoni, the author notes the option to interrogate the chart in different ways, through time (Barbeau de la Bruyère 1750b, p.7), down lines of descent (op. cit. 9), or across synchronous events at a particular moment (op. cit. 13).

A point of great importance to la Bruyère is completeness, (une notion complette de l'Histoire Universelle) (op. cit. 36). He reinforces this in the rubric of the chart with the notion of the all-encompassing glance: 'at first glance ... in that same view can be seen the entire World...' (du premier coup d'oeil ... a sous un même point de vûe, l'état du Monde entier...) (Barbeau de la Bruyère 1750b). For him as for other promoters of visualization, the eyes do the work 'two eyes (Geography and Chronology) come together so as to enlighten and direct our studies' (deux yeux (la Géographie & la Chronologie) se voient pour l'éclairer & en diriger l'étude) (Barbeau de la Bruyère 1750a, p.37). He even suggests that his map may give to man a view of all the ages similar to that enjoyed by God (op. cit. 38).

Two early chronographers remain for consideration: Jacques Barbeu-Dubourg (1709-1779) and Joseph Priestley (1733-1804). Barbeu-Dubourg is particularly strident on the contrast between chronology and chronography. The former is 'a dry form of study, laborious, unforgiving' (une étude séche, laborieuse, ingrate) – and hard to remember (Barbeau-Dubourg 1753b, p.5). Locke and du Fresnoy were among many authors who had noted the dustiness of traditional chronology. Barbeu-Dubourg develops the notion of addressing the mind through vision into one of automaticity. 'memorable events so strike the senses, organise themselves so effortlessly in the memory, and are imprinted there so strongly, that we learn almost automatically, hardly needing to think what we do' (les événemens mémorables frappent tellement les sens, s'arrangent si aisément dan la mémoire, & s'y impriment si fortement, qu'on s'instruit presque machinalement & sans trop y songer) (Barbeau-Dubourg 1753b, p.8). This is part of a general admiration for mechanism that he shares with Priestley (Boyd Davis 2010).

For Barbeu-Dubourg as for La Bruyère, completeness is an objective. His chart is 16.5 metres long and depicts all of time from the Creation to the present day on a uniform scale. His rationale for this uniformity is that the viewer need not refer to any external guidance and can assume at any point that the scale is the same. Surprisingly, he does not make any claims for the significance of empty space, perhaps because the early sheets of his chart have an embarrassing degree of emptiness. The point is made however by Priestley in relation to his much smaller – but equally uniform – Chart of Biography (Priestley 1765): '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, p.24). This is an argument for the power of visual pattern that will reveal clusters, voids and outliers. As we have discussed elsewhere (Boyd Davis et al. 2010), here continue to be good arguments for and against uniform timescales. Speaking of a pirated English version of La Bruyère's Mappemonde, Priestley attacks the lack of a uniform scale in terms of the capacity of visualisation to mislead. He is one of the few theorist-practitioners to acknowledge the dangers of a badly designed diagram, arguing that once a wrong impression (such as of timescale) has been seized through vision, no amount of ratiocination will undo the damage (Priestley 1764, p.8). He seems to recognize that this is the down-side of the benefits of rapid visual apprehension in which a few minutes' inspection 'will give a person a clearer idea of the rise, progress, extent, revolutions and duration of empires than he could possibly acquire by reading' (Priestley 1764, p.7).

Despite his reservations, Priestley makes a superb case for visualisation. He uses the example of trying to figure out the relationship between the lives of five historical figures: he allows his reader to experience the difficulty of answering questions about their relative dates before directing them to look at his chart: 'as soon as you have found the names, you see at one glance, without the help of Arithmetic, or even of words, and in the most clear and perfect manner possible, the relation of these lives to one another' (op. cit. 10). Dealing as he does in his 1765 chart with biography rather than general history (of which he made a chart in 1769), Priestley is unique in discussing the issue of context: 'a view as this chart exhibits, of a great man, such as Sir Isaac Newton, seated, as it were, in the circle of his friends and illustrious cotemporaries. We see at once with whom he was capable of holding conversation, and in a manner (from the distinct view of their respective ages) upon what terms they might converse' (op. cit. 24). Again: 'we likewise see, in some measure, by the names which precede any person, what advantages he enjoyed from the labours and discoveries of others, and, by those which follow him, of what use his labours were to his successors' (ibid).

Like Lenglet Dufresnoy, Priestley is concerned to be honest about uncertainty. Where the Abbé wants to show difference of opinion, Priestley is concerned to show doubt. His Chart of Biography is the first to use a drawn line to represent the duration of each individual life, and also to show – using one, two or three dots – the level of uncertainty of any individual's birth or death dates (op. cit. 11). Within the limits of the technologies available to him, Priestley tackles the question of justification: to say what his sources are, what principles were used to choose the two thousand names, and how he grouped them into categories (which he admits was partly pragmatic under the dictates of available space). As we noted above, the ability to represent a range of uncertainties is a prerequisite for any scholarly use of chronographics.

3. CLAIMS REVISITED

The claims that have been made for the advantages of visual timelines by their 18th century designers resonate strongly with the arguments in favour of digital data visualisation made in the last thirty years and still today. To summarise before proceeding to our own practical developments, a variety of claims were made for chronographics on the basis of intuition and personal experience which are still made now, sometimes with scientific evidence. What these leading intellectuals of the eighteenth century recognised was that visualisation provides new insights and forms of understanding. The most fundamental claim is the idea of the visual summary, uniting within a relatively small space a large number of lives, events, territories or other data elements. It is almost universally argued that the use of these graphic representations is more enjoyable and more memorable than trying to acquire the same information by reading. It is also claimed that visualisation is more direct than reading, and that it supports multiple forms of access. The notion of directness is sometimes represented as automaticity, where visual impressions are irresistible. Rarely, the concomitant dangers are also recognised.

A common claim is that for completeness: because a large amount is available within a single view it becomes possible to show 'all' the data within a chosen domain. The fact that graphics make relationships directly visible enables individual data points to be interpreted in their context. It allows patterns to emerge, revealing groupings, outliers and absences. We would emphasise that all these virtues were claimed for chronographics before any development of quantitative visualisation.

Some authors offer justification for the decisions they have taken as the authors of their diagrams, though technological constraints prevent then from doing this in situ: explanations are confined to accompanying texts. A small number acknowledge the need to represent uncertainty.

When Lenglet du Fresnoy wrote about the eyes doing more work than the mind, he anticipated the subtitle of Card, MacKinlay and Shneiderman's (1999) seminal reader on information visualisation: "Using Vision to Think". However, later authors distinguish less between the two entities of mind and eyes. Bertin (2010) extends the concept of the eyes to the visual system as a whole by describing graphical representations as a "language for the eye [which] benefits from the ubiquitous properties of visual perception" (Bertin 2010, p.8). McGormick et al. (McGormick et al. 1987) offer a quantitative reasoning in line with the argument of harvesting human visual perception for visualisations: "An estimated 50 percent of the brain's neurons are associated with vision. Visualization in scientific computing aims to put that neurological machinery to work." (McGormick et al. 1987, p.3) . Arnheim was prepared to be heavily criticised for suggesting a close pairing between perception and mind in his book "Visual Thinking" published in 1969 – "an obvious contradiction. How can there be intelligence in perception?" (Arnheim 1969, p.13) –

the close interplay between perception and cognition has since become ubiquitous and is widely discussed (Varela et al. 1992; O'Regan & Noë 2001; Noë 2004).

Another reoccurring and primary motivation behind the visual chronologies of the 18th century is the aim of making the "dry" and "laborious" (Barbeau-Dubourg 1753a) practice of engaging with data more enjoyable. It appears as if the digitisation of data has not fundamentally made it more approachable. An observation which Shneiderman shares in reference to Wurman (1990): "Information exploration should be a joyous experience, but many commentators talk of information overload and anxiety" (Shneiderman 1996). He sees the key to making data more enjoyable in the practice of visualisation and, most notably, through manipulating and interacting with these digital visualisations: "These user interface design principles for [Visual Information Seeking] have the potential to reduce our anxiety about the flood […] find patterns and exceptions, and even make browsing fun" (Ahlberg & Shneiderman 1995). Arguably, part of the suggested joyous experiences could be the mere novelty of graphical engravings in the 18th century on the one hand and the developing graphical user interfaces of the mid 1990s on the other.

In a similar manner we can find a contemporary equivalent for most of the claims made in favour of visualisation in the 18th century; the technical and philosophical contexts have changed, while the arguments substantially stay the same. Including what might be the most profound aim of visualisations: to provide new insights and forms of understanding.

"Visualization offers a method for seeing the unseen. It enriches the process of scientific discovery and fosters profound and unexpected insights. In many fields it is already revolutionizing the way scientists do science." (McGormick et al. 1987).

This "revolution" in digital data visualisation did not generally result in more sophisticated thinking about the timeline, as is it became just one of many forms of data visualisation. Hence we find less discussion which focuses on this particular form of graphical representation than in the 18th century when timelines and other time based visualisations such as those in William Playfair's Commercial And Political Atlas (1786) were the dominant form of data visualisation.

In the scientific community pioneering and dominating data visualisation in the 1980s (McGormick et al. 1987), time is seen and treated as “just another [numeric] dimension” (Kosara et al. 2004). Making time-based visualisation is simply a matter of assigning a time dimension to an axis of a scatter plot or line chart, like any other measure. Recent elaborate and rich visual timelines occupy the area of information graphics; curated and illustrative visualisations of an established topic with the aim of educating their audience. The important difference to the kind of data visualisations and visual timelines which the present paper is concerned with is that those information graphics are drafted to communicate existing knowledge and not as a method of doing research. It is on one hand this commodification of the timeline and on the other a tendency of taking time for granted in digital visualisations which is our concern. We raise the question of how visual timelines can take full advantage of the capabilities of digital technologies and support sophisticated thinking about history and historiography.

4. A TIMELINE FOR DIGITAL HUMANITIES

‘Digital Humanities’ refers to the practice of applying digital technology as an essential method in primarily qualitative scientific research. As such it does not encompass a certain discipline or scholarship. We adopt the term to discuss the characteristics of digital tools for research in history, social science, archaeology, etc.

Although data visualisation is just one example of a digital method, it has become fundamental to the area of Digital Humanities as a whole (Lunenfeld et al. 2012). Visual timelines need to match the characteristics inherent to historiography as well as to the Digital Humanities in particular. We list some of the requirements that digital timelines need to fulfill along with how they relate to early visual timelines presented above, before we focus on what we see as the primary issue that needs to be addressed; using chronographics to analyse increasingly large datasets.

1. Support complex relationships

In contrast to time-series visualisation which graph the quantitative evolution of one or more parameters over time, a visual timeline for use by a historian not only needs to make the progression of events through time evident, but also their relationships, their origin and their effects on the immediate and distant future. Martignoni's analogy of the river is a representation of time that lends itself to show such depictions: different streams of events may flow in and out of each other. Strass's Strom der Zeiten (1804) makes substantial use of this idea, most visible in his rendering of the Roman Empire, which composes itself from different rivers and splits up into several smaller streams at a later point in time. We still find the stream metaphor present in digital timelines such as ThemeRiver (Havre et al. 2002) or StreamGraph (Byron & Wattenberg 2008), but these visualisations treat every river as a separate entity.

They lack support for confluence or separation and are therefore unable to represent events which may have multiple origins or events which have no defined ending, but instead continue in several different forms.

2. Support multiple temporal granularities

Events need to be represented and comparable at different temporal granularities. Ongoing developments spanning several centuries may be examined alongside distinct incidents of variable or indefinable duration and comparisons may need to be made across time periods of variable lengths. Early timelines already struggled with this and the limitations of a physical medium. In digital media this poses less of a problem as content can be dynamically scaled and different views can be used to highlight different aspects of the data. Yet digital timelines generally take little advantage of their dynamic medium. One exception is the Continuum Timeline (André et al. 2007), which supports two views on the same timeline, allowing the omission of any arbitrary timeframe in between. Relationships between data across time are automatically accentuated as a result.

3. Support 'capta'

We use the term data visualisation to refer to the broad class of which digital chronographics are just a part. However, in the Digital Humanities context, it may not be appropriate to use the term “data” as it can be misinterpreted as something that is undoubtedly known and objectively true. Johanna Drucker argues: "As digital humanists have adopted visualisation tools in their work they have borrowed methods developed for the graphical display of information in the natural and social sciences. These tools carry with them assumptions of knowledge as observer-independent and certain, rather than observer co-dependent and interpretative." (Drucker 2011) She suggest that instead the term capta – the taken – should be adopted. Timelines for the digital humanities should in fact be capta visualisation, although for matter of convenience, we will continue using the term data visualisation, yet underlining that data should not be taken at face value. Priestley in fact acknowledges this problem in his Description (1764) and explains his reasoning behind the dates he chose to engrave in the Chart: "As the dates I wanted are given without any proof by most writers, I have always given the preference to those who give reasons for the dates they assign, or those who seem to have considered the subject with the most attention." (Priestley 1764, p.13). A digital version of Priestley's chart would not need to settle on one account, but could give its user access to several possibilities along with a reference of their source.

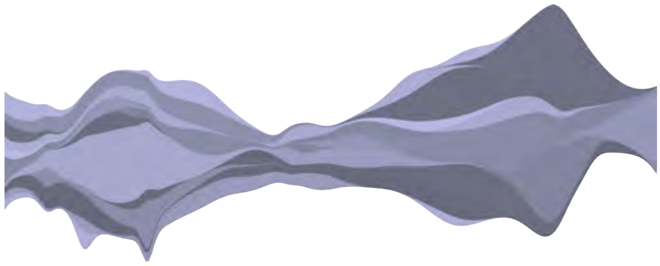

Figure 4: The river metaphor remains being used for time related visualisations, such as in this implementation of Byron & Wattenberg’s (Byron & Wattenberg 2008) StreamGraph. Source: http://bl.ocks.org/mbostock/406095

4. Support temporal conflicts and uncertainties

When dealing with the temporal aspects of historic events one generally faces varying kinds and levels of uncertainties and doubts; be it through incomplete recordings of dates, varying and conflicting sources, incompatible calendars or ambiguities in interpretations or translations. The problem of uncertainty and inaccuracy is not unique to historic data visualisations, but it is more complex and less quantifiable than in other fields where uncertainties originate largely from statistical deviations or measuring inaccuracies. A digital timeline therefore needs to support such conflicts and needs to allow access to the reasoning behind represented events. We have discussed elsewhere in more detail the issues around visually representing uncertainty in digital timelines (Kräutli & Boyd Davis 2013). In this paper we only want to draw the attention to the fact that, in contrast to most modern timelines, this problem has been addressed in the work of Joseph Priestley in the manner discussed earlier.

5. Support large datasets

Perhaps the most far-reaching consequence of the digital is that information technology enables larger datasets to be processed than ever. It is essential that visual timelines are able to scale to datasets which contain thousands and even millions of records if they should be useful as a digital research method. Paper timelines could in principle be of unlimited size, such as the 16.5 metre design of Barbeu-Dubourg, but suffered from many fundamental problems – not least the difficulty of finding information within a large physical space. Paper timelines were naturally fixed in scale: ‘zooming’ was achieved by the user moving nearer or farther from the paper, but digital technology allows us to be more ‘smart.’ Therefore we conclude this paper with a summary of some work we have undertaken in this direction.

5. SEMANTIC ZOOMING TO VISUALISE LARGE DATASETS IN DIGITAL TIMELINES

We have described some of the challenges that digital timelines need to overcome in order to be a valuable research methods for historians and other practitioners of digital humanities. We think that most of these problems can in principle be solved and some of them, as we have shown, have already been addressed. Yet there is still a lot of research necessary and digital technology has substantially influenced the way we do research. But how exactly has Digital Humanities changed the nature of the work by historians, archeologists or social scientists? There are generally two directions: digital technology can enable research which would not be possible with any other methods, such as projects that involve born-digital archives. The other direction, to which a major part of work in the digital humanities belong, are projects where digital technology is used for an increase in efficiency. In practice this means that research is concerned with much larger datasets than would be manageable by individuals. For example, Stanford's 'Mapping the Republic of Letters' project is based on a dataset containing 15,000 letters and Google's nGram viewer analyses data from more than 30 million books. The UK National Archives has 20 million descriptions of records in its online catalogue. The Tate Gallery has recently put metadata for around 70,000 artworks on Github for open use. Cambridge University Digital Library has put online 63,697 images from the Board of Longitude. Visualisations need to be able to handle such quantities of data.

5.1. Visualising large datasets

Methods for visualising large datasets work by either reducing or reorganising the displayed data. To the first category belong methods such as clustering and sampling, to the latter techniques such as jittering, dimension reordering or distorting:

Clustering (reducing)

If chronographics can be thought of as visual summaries, as the pioneers suggested, clustering techniques make possible localised summaries within them. Data points which are close according to a defined similarity measure and threshold (e.g. distance in time) are grouped together and represented as a single entity. This technique finds wide applications in timeline visualisations, essentially producing a visual summary of the dataset (Huynh et al. 2005; Alonso et al. 2009; Krstajic et al. 2011).

Sampling (reducing)

The amount of data is reduced by taking a sample from the dataset, either randomly or curated. It can be trivial to implement, yet it is not widely used in data visualisation in general (Bertini 2007) or timelines in particular.

Jittering (reorganising)

Jittering displaces data points locally in crowded areas of a visualisation. Such 'smart' reconfiguration approaches are used, for example, in 'Excentric Labeling' [sic] (Fekete & Plaisant 1999) where spatial labelling conflicts are automatically resolved on a local basis. We have previously developed a time-aware version of this technique (unpublished).

Dimension Reordering (reorganising)

This technique changes the order in which data dimensions are displayed on screen so as to position similar parts of the dataset closer and make patterns and correlations more visible. It would lend itself to be implemented in a timeline, but so far we have not seen an example of dimension reordering in use in a timeline visualisation.

Distorting (reorganising)

Distortion on the other hand is a technique that is more common for timeline visualisations. Generally, the time axis is locally distorted by, for example, a user-controlled lens (Dachselt & Weiland 2006; Ajanki & Kaski 2011). As Priestley (1764, p.8) noted, if non-uniform timescales must be used, problems are certain to arise if 'the notice which is given of this change is not sufficient to correct the error of the imagination.' We elsewhere recommend (Boyd Davis 2010) that uniform timescales be regarded, and visually treated, as the default, and that any local alterations should be clearly indicated to the user. Nowviskie (2004, p.246) and Drucker (2011) have offered the word 'inflection' for such temporary and contingent alterations – a useful term without the pejorative undertones of 'distortion'.

5.2. Semantic Zooming

We present our work on semantic zooming for timeline visualisations, which is a variant of the sampling techniques. As a data-reducing technique, it scales well to large datasets of potentially even millions of events, as the number of events that get drawn on the screen can be kept in line with the capabilities of the system and the user.

Figure 5: Zooming in on the summarised timeline (left) reveals more details about the dataset (right)

Like the chronographers of the 18th century, we take our inspiration from geographical maps. At different scales maps represent not only geographical features at different sizes, but also include different kinds of data: a 1:100,000 map shows major roads and borders of cities, while a 1:25,000 includes neighbourhoods, individual buildings and byroads. Digital maps zoom easily between scales. As one zooms closer, more and more details become visible. Semantic zooming adjusts not only the size of the representation but also the kind of information at different zoom levels.

Our prototype visualisation consists of a timeline view in which time runs horizontally from left to right. The view can be panned (by dragging with a mouse or touchpad or, on touch screen devices, with the finger) and zooming is controlled by either a scroll gesture (on mouse or trackpad) or by a pinching gesture (on touch screen devices). The timeline follows the common visualisation paradigm – with events represented by lines or bars – first introduced by Priestley (1764). We consciously opted for an established model of a timeline which users will be familiar with in order to better assess our changes and additions to this model. Initially, the events are ordered vertically by start time. On the right of the timeline we position histograms and word clouds which allow the dataset to be filtered according to desired parameters. Above the timeline is a slider which controls parameters of the semantic zooming which we discuss later.

In maps, semantic zooming is driven by an inherent hierarchy of the displayed information: neighbourhoods belong to cities, cities to districts, etc. Not every dataset that a historian would want to visualise in a timeline contains such a hierarchy. We therefore need to define a measure that controls which events are visible at which zoom levels of the timeline; a dynamic hierarchy. In this early prototype we took the authority of selecting the parameters that control the hierarchy. At a later stage, we will make this user-definable.

As an example we chose the dataset of artists represented in the Tate collection, which is freely available via GitHub (Tate Britain 2014).The datasets contains the metadata of – at the time of writing – 3471 artists including their lifespans, dates of birth, associated art movements and number of works in the Tate collection. We represent the lifespans and names of artists in our timeline view and use the number of works to derive the hierarchy. Every artist in the view is automatically assigned a weight value between 0 and 1, which corresponds to the number of an artist's works in comparison to the maximum number of works by any artist in the Tate collection. In this way we emphasise the 'popular' artists, but we could also have reversed the mapping, focusing on the less represented ones, or freely choose a different measure, such as for example the distance of the artists birth place from the geographical location of the Tate collection. Allowing as wide a range of measures as possible, will, we suggest, be most likely to lead to the discovery of unexpected new patterns. It is essential that data visualisation optimises the likelihood of unforeseen insights.

Two dynamic threshold values define how the events are drawn on the screen in three stages:

1. events with a weight value below the first threshold are hidden
2. events with a weight value below the second threshold are drawn as lines without titles
3. events with a weight value above the second threshold are drawn as bars with titles

This results in an overview of the dataset with the most important events prominently visible and a selection of events indicated as lines. A large part of the dataset remains initially hidden and gradually appears when zooming closer.

The two threshold values can be adjusted with the aforementioned slider above the timeline. Upon first viewing the timeline we are presented with the lifespans of the Tate's most prominent artists such as Turner, Beuys and Warhol. They form two separate clusters, one around the year 1800 and another centred around 1950. We get a sense of the content of the collection: how many years it spans, who the main artists are, which time periods the collection focuses on. All this we see "in one glance", as Barbeau de la Bruyère (Barbeau de la Bruyère 1750a) wrote; however it is important to remember that what we are presented with is sampled and curated by our defined parameter for semantic zooming as well as our choice of ordering dimension. Hence the two clusters do not represent the age distribution of artists in the Tate collection – this would be visible in the histogram – but the lifetimes of the artists whose work is most prominently represented in the Tate collection. Without this additional insight the chart could easily be misinterpreted, which is why we try to give the user as much control as we can over the parameters that drive the visualisation.

In an initial pilot study users appreciated and made heavy use of the tools for filtering and sorting that are already available. The filters are all linked in real-time and users appreciated the possibility of 'brushing' through one dimension, such as the birth year of artists, while simultaneously observing e.g. the development of art movements over time. Our initial observation confirmed that semantic zooming was useful for getting an overview as well as detailed insights into a dataset presented on a timeline. However, the behaviour of the zoom does not match the users' initial expectation. Zooming is normally associated only with a change of scale and not a change of detail. Digital maps form an exception which does not translate immediately to other forms of visualisations such as timelines. After spending some time interacting with the timeline and the semantic zoom users begin to understand and make use of its function.

6. FURTHER WORK

We presented the challenges around digital visual timelines with a particular focus on the representation of large datasets. Our considerations and efforts in the area of semantic zooming have so far mainly been on its technical aspects. There are however usability problems to consider, the most important one being: how is the user made aware of the data that is invisible at certain zoom levels? There is an inherent danger when representing data visually of it being incompletely or dishonestly translated by the data visualisation or the visualisation itself being misinterpreted by the user. In order to have a better understanding of how our chronographics are interpreted by the users and what kind of insights researchers are able – and unable – to get, we will conduct further user studies.

So far we have discussed the technique of semantic zooming applied to chronographics in order to tackle the issues around visualising large datasets. A range of other techniques, as outlined in section 5.1, have been developed for the same purpose in data visualisation, but not all of them have been applied to time-related visualisations. Similarly, the requirements for digital timelines discussed in section 4 give an impression for the amount of work still required in this field.

What is remarkable is how little, in principle, the ambitions, the working concepts and the problems around chronographics have changed since their beginnings in the 18th century. Digital technology has mainly been responsible for an increase in the amount of data being analysed, as well as for an increasing accessibility of data. We would like to see digital chronographics take full advantage of these vast resources as well as learn from the ambitions of the early chronographers in order to develop timelines that are more than simple illustrations, namely tools for understanding and the production of knowledge.

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