Visible Language 49.3

the journal of visual
communication research

special issue

critical making

DESIGN and the DIGITAL HUMANITIES

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December 2015

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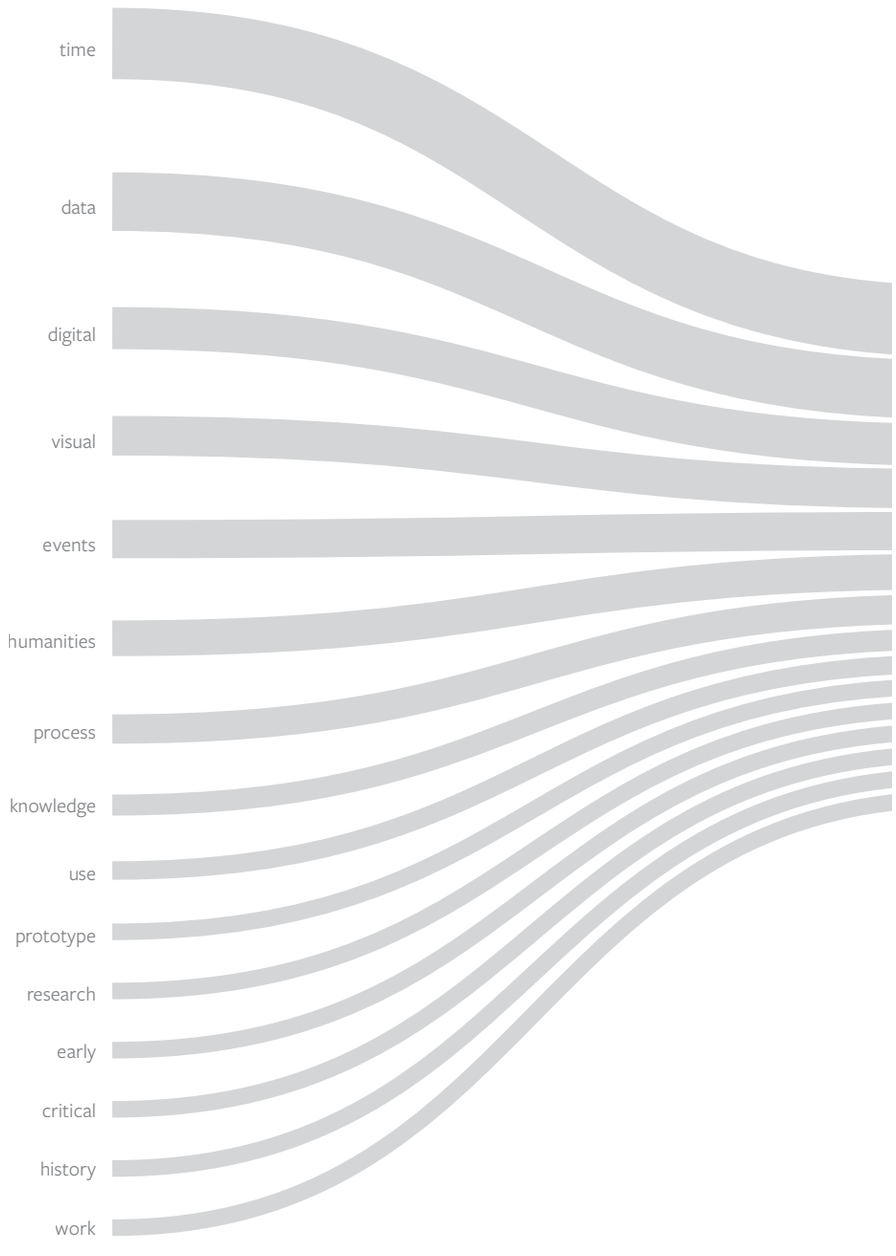

The Idea and Image of Historical Time:

Interactions between Design and Digital Humanities

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Florian Kräutli

Abstract

The paper addresses the relationship between design and the digital humanities, asking what each can learn from the other and how they may make progress together. The focus is *critical making* in chronographics — the time-wise visualisation of history — based on the authors' historic research and current practice in visualising collections of cultural objects and events. This is situated in historic and contemporary contexts, arguing that the eighteenth century origins of the modern timeline have useful insights to offer in terms of objectives and rationale. The authors advocate a critical approach to visualisation that requires both design and digital humanities to face up to the problems of uncertainty, imprecision, and curatorial process, including in relation to time itself.

Keywords: chronographics, curating, design, dates, digital humanities, timeline, uncertainty

Introduction

In this paper, we explore the interaction between designers and humanists in the context of our work on time-wise visualisations for research in digital cultural collections. The digital humanities have introduced humanities researchers to 'making' as a method for knowledge production, as well as to the idea of visualisations as research outputs, which is leading to increasing collaboration and cross-fertilisation between the fields of design and humanities.

We suggest that, in the context of time-wise visualisation, scholars were already adopting 'design methods' in the eighteenth century by creating new data visualisations of temporal data in order to understand and communicate. They combined graphic invention, advanced technologies (such as copper plate engraving and techniques borrowed from cartography), and new approaches to humanistic knowledge, particularly in terms of mathematisation and mechanisation. We show that then, as well as now, there are important insights to be gained through the act of making, as well as through interacting with the created digital artefacts, and that those insights benefit both design and the (digital) humanities.

Our work has led us to grapple with a number of issues. Our commitment to making timelines into serious tools that match the needs of historiography requires us to address head-on the problematics of time as a metrical framework, seeking benefit in time-wise visualisation despite its apparently mechanistic character. We deal with data that is messy, partial (often in both senses – incomplete and skewed), and flawed. These failings extend to the very numbers we depend on for dating objects, events, and records.

The digital humanities face criticism for relying on mechanical methods for what should be substantially an interpretative form of scholarship (Anderson, 2007; Borgman, 2009; Drucker, 2011; Swierenga, 1974). However, the humanities have long been intertwined with mechanical methods and mathematical concepts. While we may take most of them for granted and as essential, it is worth considering that even by a trivial act such as positioning historical documents by date, we make use of a mechanical, arithmetic model: Newtonian time, named after its most prominent proponent. Newton considered time to be an absolute, uniform frame of reference where events could be 'located' independent of other events or external perceivers. Time, according to Newton, is "absolute, true, and mathematical" (Newton, 1687), a fundamental quantity like length or mass, which can be measured and expressed in a manner that may be universally agreed upon. In the eighteenth century, such thinking led to geography and cartography being treated as models for representing historical time (Boyd Davis, 2015b).

Without this fundamental shift in thinking about time as a number, and Descartes' proposition that anything that can be expressed in number can be represented graphically (Descartes, 1996), true timelines that map durations to graphical space would not be conceivable. This transition, from studying historical data based on lists and tables of time to Cartesian graphical 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 where events are situated.

To model history on such a basis is to make an emphatic decision. Such numeric and apparently objective models of time have famously been contested. Bergson (1950) discusses time in relation to consciousness. He distances experienced (concrete duration) from mathematical time (abstract time), the latter seen by Bachelard (1963) as a sequence of discontinuous, countable instants. Bachelard, as a philosopher of science, favored a quantified model of time, for only what can be expressed in numbers would, in his view, count as scientific. By contrast, Bergsonian duration is "a qualitative multiplicity, with no likeness to number" (Bergson, 1950, p. 226). His duration is unique and extends continuously from past to present. Of course 'scientific' time is no longer the simple uniform progression from past, to present, to future that non-scientists sometimes like to suggest. Einstein introduced a kind of subjectivity with the theory of relativity, and time's very existence is repeatedly questioned, including in the 'hard sciences' such as physics (Barbour, 1999). For Gödel, too, (Weinert, 2013) time is unreal, a conclusion that has been reached by thinkers such as Spinoza, Kant, and Hegel (McTaggart, 1993), and many others throughout history.

In the field of information technology, a number of innovations are introducing interpretive and subjective (Drucker & Nowviskie, 2003), complex and uncertain (Kräutli & Boyd Davis, 2013; Meeks & Grossner, 2014), and social (Martin, 2010) models of time. Nevertheless, Newtonian time is still the prevalent underpinning model in computing; and, if we keep in mind that it is just one of many, it has considerable merits for analysing data through visualisation by providing a unified frame of reference that can be easily mapped on to the numerical space of a digital screen. Arguably, there are also few alternatives when it comes to working with existing datasets. While the limitations of available software tools for humanities research have been identified since the 1980s (Winchester, 1980), early efforts in developing database tools specifically for humanities computing (Thaller, 1987) found little acceptance. Most cultural datasets have therefore, whether thoughtlessly or out of necessity, been created with simple models of linear time, and without many of the qualifiers — relative dates, levels of precision, identification of authorship, etc — that would be necessary to sustain other approaches.

We present first some historic examples of visual chronologies such as timelines — a class of visualisation we will refer to as chronographics — and discuss the arguments put forward by their creators. We see these pioneering works as a form of research through design, as their makers not only had to design new graphical formats, they had to develop a new visual rhetoric and, most importantly, explain and reflect on their ideas, processes, and rationales. Today, it is rare for designers to have to defend and justify their decisions in relation to visual representation of time. Until recently, chronographics have largely escaped serious study. This 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 (Kwan, 2010; Rose, 1993), while the awareness that maps represent particular ideologies, parties, and claims has even made its way into populist academic literature through the works of Monmonier (1996; 2008). Chronography, however, unlike cartography, is generally seen as simple, even as "a bit of banal tedium" (Behrendt, 2011), and as a merely technical design problem. We argue that chronographics both require and enable critical thinking.

Our research method

Our methods are based on iterative design of functional visualisation prototypes for digital cultural collections. A core element of this process is a constant evaluation of the created artefacts in the form of critical reflection and ongoing dialogues with museum curators and archivists, who are both experts and the future users of our visualisation tools. This is a form of *critical making* (Ratto, 2011) in which we emphasise iterative and collaborative methods and use the collaborative working process itself as the locus of evaluation, rather than employing a separately designed user-testing process.

We also assume, as was recognised early in the years of Design Research as a discipline, that the questions, issues and problems to be interrogated and presented are reformulated during the design and development process (Archer, 1968). The creation of a prototype and the subsequent interaction with it constitute the enquiry by raising new research questions that emerge during development and evaluation of the prototype and by supplying evidence for addressing the original research questions. Prototyping acts as a way to instantiate ideas and hypotheses and as a method to generate knowledge by reflecting on the creation process and interacting with the created prototype.

Our prototypes are based on existing cultural datasets and thus reflect the challenges of time-wise visualisation in real-world applications. We work with publicly available datasets as well as data we have obtained directly from the institutions we collaborate with. In terms of our technical methods for realising our prototypes, we rely on standard web technology such as HTML and JavaScript together with the open source visualisation library d3.js (Bostock, Ogievetsky, & Heer, 2011).

Early Chronographics

In 1718, Girolamo Andrea Martignoni (died c.1743) published a large, engraved chart of history inspired by geographic maps and centered on the Roman Empire, together with a substantial *Explication de la Carte Historique de la France et de l'Angleterre* (Martignoni, 1721) and a similar volume on Italy and Germany. He presents his chart as a visual summary of history, "par une nouvelle invention, de faire voir en abrégé dans une Carte, toute l'Histoire principale de l'Empire Romain" (Martignoni, 1721§1). He also identifies multiple forms of access, in that there are three different ways of

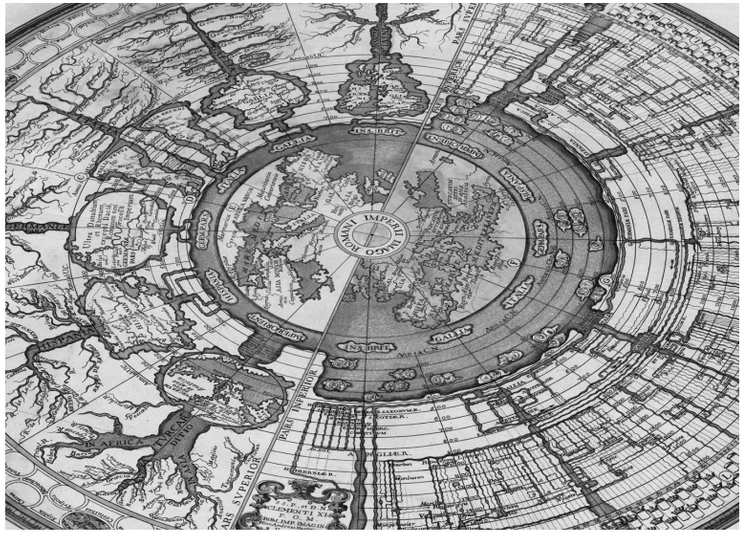

Figure 1. Martignoni, 1718. Chart of the Roman Empire. Turin: Tasniere. 56cm x 57cm. Collection / photo: Cartographic Institute of Catalonia (Creative Commons BY-NC-ND 3.0).

interrogating his chart: tracing events and successions, following centuries, and tracing the histories of major families. These are facilitated by the representation being diagrammatic rather than textual. Martignoni also claims that the use of his chart is enjoyable and that it 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, 1721§1). The notion of visual presentation providing a more enjoyable encounter with history recurs in many later authors and can be regarded as a primary motivation for chronographic invention.

The Abbé Nicolas Lenglet du Fresnoy (1674-1755) similarly states 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, 1729). 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") (p. 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, 1729). Few chronographers since have troubled themselves with uncertainty of any kind, succumbing to the temptation to make clean, uncluttered, unequivocal charts, which perhaps explains why timelines are not generally regarded as a serious tool for the historian.

While Martignoni favoured a design based rather literally on metaphors of topographic features and cartography, Joseph Priestley (1733-1804) and Jacques Barbeu-Dubourg (1709-1779) both produced 'mappings' of a more abstract kind, timelines that graphically map events on a mathematical diagrammatic timescale, an 'ocular demonstration' of Newtonian time (Priestley, 1764). Priestley is one of the earliest to graphically address the problem of uncertainty, as described below, which is so often swept aside by subsequent chronographic designers.

Barbeu-Dubourg's chart (Barbeu-Dubourg, 1753) is 16.5 metres long and depicts all of time from the Creation to his own days 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 to reveal clusters, voids, and outliers — though Priestley, in an untypical lapse of acuity, fails to make any distinction between lack of events and lack of data for his 'empty' periods. As we have discussed elsewhere (Boyd Davis, Bevan, & Kudikov, 2013), there continue to be good arguments for and against uniform timescales. Speaking of a pirated English version of La Bruyère's *Mappemonde* (1750), 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 recognise that this is the downside 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). Key characteristics that La Bruyère sought in his own diagram were "order and precision" ("ordre et precision") (Barbeau de la Bruyère, 1750), surely indicators of a then new mechanical-mathematical approach to time (Boyd Davis, 2015a).

Despite his reservations, Priestley makes a persuasive 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" (Priestley, 1764, p. 10). Dealing as he does in his 1765 chart with biography rather than general history (he made a chart of the latter in 1769), Priestley is unique in discussing the issue of individual 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 [sic]. 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" (Priestley, p. 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" (p. 24).

Like Lenglet Du Fresnoy, 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 (Priestley, p.11). Within the limits of the technologies available to him, Priestley also tackles the question of justification: to say what his sources are, what principles were used to choose the two thousand names he represented, and how he grouped them into categories (which he admits was partly pragmatic under the dictates of available space).

Process

In his Description, Priestley stressed his view that he was merely an "assistant to great Historians, Chronologers, and Biographers" (Priestley, 1764, p. 4) in the sense that he claimed not to have made any major discoveries himself. All he professes to have done is to represent the data that scholars had gathered before him and communicate their findings to a wider public. In contrast to Priestley, we are in the privileged position to have been able to work closely together with these 'data-gatherers', the curators and archivists who sometimes were the very scholars who had produced the digital datasets we visualised and, in all cases, were very knowledgeable about the contents and origins of the data. Collaborative efforts between humanities scholars and designers have proven to be challenging at times, but nevertheless insightful and beneficial for both (Caviglia, 2013; Pellegrini, Caviglia, & Ciuccarelli, 2013; Uboldi et al., 2013).

The prototypes we discuss in this paper offer snapshots of our iterative design process. They are indicators of the numerous paths we explored, focusing principally on the works of Benjamin Britten as represented by the digital records of the Britten-Pears Foundation in Aldeburgh, UK. Seeking an institution willing to share not only their datasets but also their expertise, we were lucky to work with Dr. Lucy Walker, Director of Learning at the Britten-Pears foundation, who was not only eager to help us but had already experimented with simple visualisations herself. Once we had prototype visualisations to offer, it became easier to encourage other scholars and museum professionals to collaborate, even where they had no prior experience in visualisation. In the following account, the remarks by these various curators are distinguished by their initials.

We encouraged curators to come up with questions that they would like to have answered through visual interfaces — assignments or design briefs in a sense — before

we let them see and interact with our prototypes and, in some cases, even before we had visualised any of their data. Typically, their questions related to ongoing discourses among the experts in their particular field, perhaps related to common beliefs and assumptions about the items in the collection or their creators, for which a visualisation might provide evidence, or maybe disproof. Sometimes the questions would require additional data to be gathered or digitised and generally revolved around the contents of the collection as well as notable individuals associated with it.

Before we could get to the content, we had to concern ourselves with the form, the structure of the digital catalogues. As our own interest was in the visual representation of temporal events, we paid particular attention to the way dates are specified and stored in the database. The Britten-Pears dataset proved to be an exceptionally complete collection in terms of dating: every single item contained a date of composition. However, curatorial staff warned us that the composer sometimes retrospectively wrote dates onto undated items from his earlier history, a reminder that dates — as much as any other historical data — must be considered with caution. Dates were specified in a wide range of granularities: Almost half of the dates were set by the exact day, some contained a month and a year, while just a third of the dates were defined by year only.

Most digital collections we worked with stored dates as a pair of values denoting an earliest and latest date, typically bracketing the date of production of an artefact. Additionally, the date is generally stored as free text: it is this representation that the curators work with and is exposed on a website when the collection is accessible online.

Often, there is a significant discrepancy between the free text that the curator enters manually and the numeric date pairs that lie 'behind' them and are sometimes generated automatically. The numeric values for the pairs of dates are typically stored as years, even in cases where more precise information would be available in the written date. In other cases, where the precision of the known date is less than a year, the numeric dates are set as a precisely defined range of years. In the Cooper Hewitt objects database, for example, 'mid-20th century' becomes 1940-1958; 'possibly ca. 1960' is stored as 1955-1965; and '1946 or later' is quantised to 1946-1989. Thus data-formatting and processing protocols produce their own, sometimes unhelpful, effects on the quality of the data, typically implying greater precision than was originally available—clearly a process that should be of concern in any critical approach to using time as the basis for knowledge production.

Dates, history and curatorial practice

In day-to-day use, a curator may only be concerned with the textual dates, but in order to map records computationally on a visual timeline, we have to rely on their numeric representations. Having spotted some of these problems in the datasets, we were prepared to see these discontinuities reappear in prototype visualisations that we made in order to get an impression of the size, composition, and temporal scope of the collection.

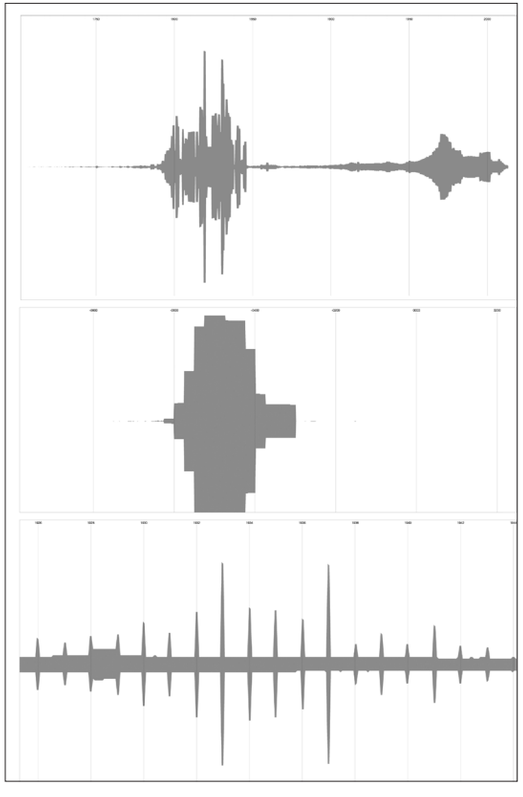

Figure 2. Kräutli, 2014-2015. Institutions use different strategies when dating their items, as we discovered through these visualisations. Tate (top) specifies exact years, while the dates in Oxford's Beazley Archive fall in regular intervals of 50 years (middle). Cooper Hewitt (bottom) predominantly dates either by year or decades, which is visible through the regularity of the spikes and planes.

The extent of the irregularities that the visualisations exposed nevertheless came as a surprise to us and caused some embarrassment among the curators: Modern paintings appeared in Roman periods, photographs depicting contemporary street scenes were placed at the beginning of last century, compositions seemingly were performed before they were written, and works that must have taken years to produce all happened to have been conceived on the exact same day.

We explored the sources of these irregularities in the visualisations in dialogue with the curators. Some errors we could quickly identify as caused by the collections management system, where the software misinterpreted the data that a user meant to enter: a specification like '17th century design, produced 1920' might have been translated to 1600-1920 in numeric terms.

But what would be the 'correct' date of such, or any historical record? By having to ask this question for practical reasons in order to position visual marks on a timeline, we addressed a delicate issue in historiography around the recording and certainty of events in general. "In the history of technology at least, historians have only been interested in innovation, the moment of genesis" (DR), a curator responds, which is why objects in museums often only carry a single date, concealing the events

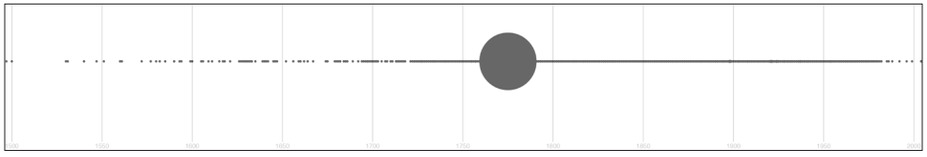

Figure 3.
Kräutli, 2013.
A sketch visualisation of the Tate dataset. Each artist is represented as a bubble, arranged horizontally by birth year and sized by their number of works in the Tate collection. The large bubble stands for J.M.W Turner, who dwarfs the other artists by being disproportionally present in the Tate collection.

that lead to their creation as well as their history up until the present. We can assume that events did not just happen without any background process, that objects or works of art may have taken a considerable amount of time to be conceived and manufactured, and that we cannot be sure of when the various creative processes began or ended. Still, by pinpointing an event to a precise date, we generally choose to suppress this uncertainty. At the same time, institutions may be forced into a position, as the preservers and authorities of a collection, where they need to demonstrate a level of expertise and certainty that is not really attainable. "Twenty years as a curator, I was always forced to be certain about things I wasn't certain about," (DR). Furthermore, historic knowledge needs to be expressed in a format that is compatible with cataloguing structures. While these have been in place also prior to their digitisation, in cases such as dates, digital databases often allow for even less flexibility than their analogue predecessors.

Had our brief been to design a visual timeline to appear in an exhibition, we might have been keen to tidy up the display, correct supposed errors and, if necessary, omit data in order to get a clear picture that communicates a coherent history to the public. However, our own view is that such tidiness, even for public consumption, risks presenting a deceptive view of historical events, and of the nature of historical knowledge itself.

Led by our conversations on the uncertainties around dates, we decided to instead explore and emphasise these inconsistencies through prototype visualisations. Our first iterations focused on the representation of uncertain events. We developed a format that allowed us to model uncertainties both mathematically on the data level as well as graphically in timeline visualisations (see Kräutli & Boyd Davis, 2013). However, we found that a visual rendering of imprecisions might itself convey a greater level of confidence in the uncertainty of events than is supported by the data.

We therefore decided to try a more playful approach that utilises rather than models uncertainties around dates. In a later prototype (Figure 5), each record is represented as a dot, which is pulled towards its designated position on a horizontal time axis with a simulated gravitational force that is proportional in strength to the certainty of the date. The technique, which is borrowed from a force-directed graph visualisation method (Fruchterman & Reingold, 1991), causes the dots to align themselves in a fluid motion — a visual effect that curators found very appealing. There were, nevertheless, two downsides to this method, which we sought to tackle in our latest prototype iteration. On a technical level, the approach did not scale well to datasets larger than a few hundred items due to the complexity of the physics simulation. On the side of the users, unsurprisingly, the curators found it difficult to interrogate records that were moving around constantly. We realised that we had to

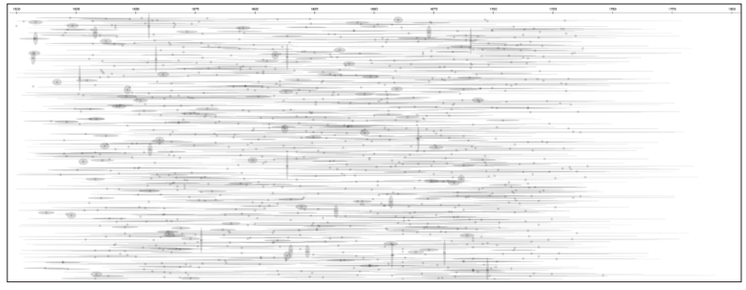

Figure 4.
Kräutli, 2012. An early prototype iteration which maps events as disks, distorted according to their level of uncertainty. The data for this visualisation is generated randomly and does not correspond to a real-world dataset.

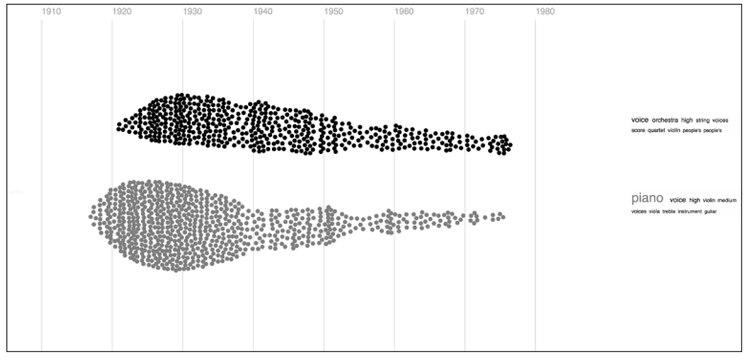

Figure 5.
Kräutli, 2013.
Separating Britten's works with the word 'piano' in their subtitle from all other works exhibits a bias in the collection, or in the way it is catalogued. Note that time-wise visualization reveals how the skew towards 'piano' arises particularly in the composer's early compositions.

find a way to retain accessibility to individual records, even in collections that span hundreds of thousands of them.

We built a prototype visual layout we developed around a strategy we call Temporal Jittering. The diagram resembles a representation of a sound wave, but is actually composed of individual circles, which are positioned on the horizontal time axis anywhere within the timeframe allowed by their date brackets and vertically stacked by order of accession, and only after all possible horizontal positions have been occupied by other items. This allows us to generate a compact and aggregated overview of an entire collection, which can seamlessly be navigated by panning and zooming in to reveal individual records, along with their associated images where these are available. Essentially, we are exploiting the fact that we know that item dates have, in reality, a greater latitude than the data records seem to imply, in order to accommodate a more densely packed display than would otherwise be possible.

Again, we sought the expertise of curators and scholars in order to critically evaluate our prototype visualisation. The overall shape of the diagram gave an impression of the dating strategies employed by particular institutions. Cooper Hewitt, for example, tends to date objects either by year or by decade, while all the dates that the public Tate collection contains are set by year. The records in Oxford's Beazley Archive, a collection of imagery of ancient Greek pottery, appeared to be dated primarily in periods of 50 years, a regularity that previously went unnoticed (Figure 2).

The entire visual timeline functions like a digital map of the collection and enables curators, sometimes for the first time, to get an impression of the size and scope of their collection. "What I find really appealing [is this] ability to see the entire database in a sense. You literally see it all" (PS). Curators appreciated the notion of being able to see everything, and then having the possibility of getting a narrower view, to look at the visualisation in more detail. "It is a really useful and intuitive way of filtering the data. I don't think we can currently filter down to that level of detail" (LW). This behaviour, and how the visualisation affords it, is very much in line with Shneiderman's visualisation mantra, "Overview first, detail on demand" (Shneiderman, 1996). Although Shneiderman has been criticised for a lack of evidence supporting his argument (Craft & Cairns, 2005), we have observed on a number of occasions that curators were enthusiastic for these all-encompassing views, echoing the opinions of their eighteenth-century predecessors for whom totality was also a key consideration (Boyd Davis, 2015a). Shneiderman later proposed a possible application of his mantra by enabling seamless transitions between aggregated overviews and atomic representations (Shneiderman, 2008), a behaviour our visualisation affords by letting users zoom in on the overview down to the level of individual records.

The visualisation also drew our attention to certain anomalies in the collection, which often manifested themselves as suspiciously regular clusters: peaks in the overall shape of the collection, groups of records that had the same or very similar-looking images associated with them, or sudden increases in numbers of items.

What these anomalies represented were not so much a reflection of the content of the collection, but traces of curatorial decisions as well as residues of the history of the collecting institutions. When looking at the database of the Britten-Pears archive from the perspective of the visualisation, it seems that Britten wrote primarily for the piano although, according to their curator, "he is not known at all as being a piano composer, and there it is" (LW). What the visualisation revealed was not so much representative of Britten's oeuvre, as of the decision to classify most of his many childhood works as piano pieces.

A similar bias appears in the Tate digital collection. In this particular case, we did not collaborate with any curator of the Tate, but retrieved the data from their public GitHub repository (Tate Britain, 2014). According to these records, J.M.W. Turner produced close to 40,000 works, accounting for the majority of the entire Tate collection. The reason for this anomaly lies in both the composition of the collection and in the works' classifications: "The Tate holds the Turner Bequest on behalf of the nation, which comprises a large number of Turner sketchbooks. Each page of these sketchbooks is classified as an individual artwork on paper, which makes up the lion's share of this rather singular collection" (Barrett-Small, 2013). Such characteristics could equally have been identified through statistical analysis, but the visualisation made them immediately apparent; and, crucially, without explicitly having to look for them, the visualisation produced new knowledge in a highly accessible form.

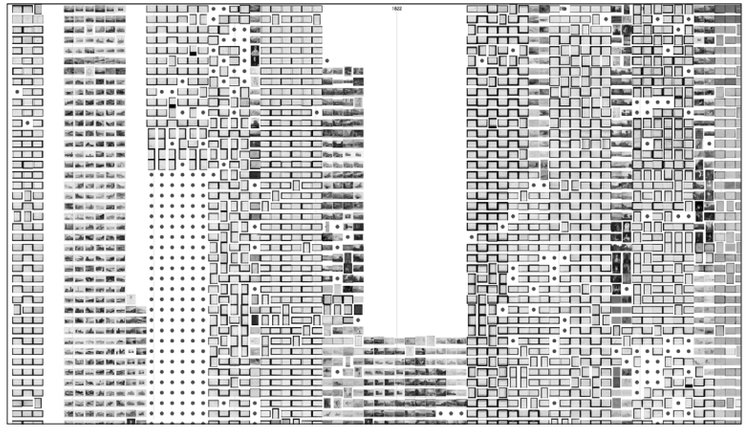

Figure 6. Kräutli, 2014-2015. A closeup view of the timeline of works in the Tate collection that have been produced around 1820. It becomes evident that most of the works in the collection by J.M.W. Turner consist of sketches and prints, rather than finished paintings, where every page has an individual record.

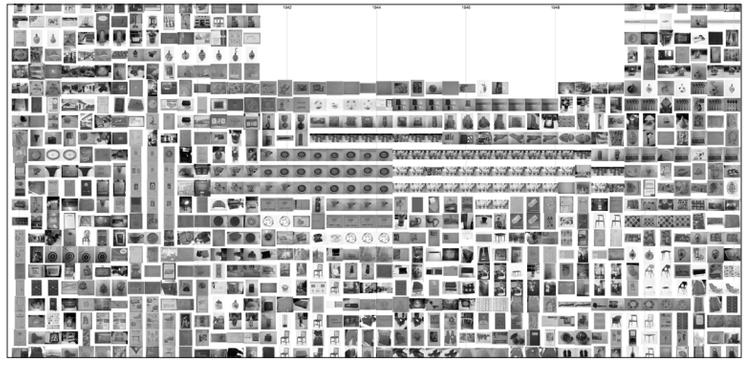

Figure 7. Kräutli, 2015. Where records have associated images, the visualisation may give an impression of the contents of a collection — in this case the collection of the Geffrye Museum, London. The images also allow for insights into curatorial practices. Two clusters of similar looking images appear in the centre of this screenshot, bearing witness to two sets of tableware that have been acquired around the same time and their parts catalogued as individual objects.

The questions that curators were requesting visualisations to address were initially primarily pointed 'outwards,' toward issues relevant in their field for which their archives might hold the answers. Through continued collaboration, and interaction with our prototypes, the focus of our discussions turned inwards, towards the history of the datasets and how these digital collections could be read as a mirror image of the institutions that produced them: "The shape of the collection is not an objective archive [...] [it] is determined by the administrative structure and preservation criteria — what the museum deemed important enough" (RT). Several curators suggested including 'hidden data' in the visualisation, the kind of data that is not entered with later use in mind, but is created by the database management systems, such as the digital traces of the people who edited it: "As much as you try to make [collecting] a scientific process, through policies, procedures, and guidelines, it's always based on the whim of that panel of curators. [...] In the way you present it by curator, you see where trends in collecting have taken place, the themes different curators were

having in the development of the collection." (AR) — and even: "It could be showing where an out-of-control curator has gone mad and acquired a lot of material." (MT).

For professionals who work with digital collections on a daily basis, the fact that these biases exist is not news; however, it is not something that institutions generally like to admit – "Museums have practiced the concealment of uncertainty" (DR). As outsiders to the field of museology, creating visualisations of museum datasets and discussing our prototypes with experts allowed us to get a peek into the subtleties, imprecision, and messiness of digital collections. For curators and archivists, visualisations served as a way of providing evidence for their tacit knowledge: "It brings a real vision to the problems we're constantly thinking about" (AR).

Discussion

Our own efforts in visualising cultural data over time share with the works of the early chronographers (discussed at the beginning of this paper) the observed merits of being able to visually grasp a dataset in its entirety, the ability to discover and study emergent patterns, and the pleasure people find in visually interacting with these datasets. The process of designing visual timelines has served as a way of problematising seemingly trivial notions of time and graphical expressions of temporalities.

Collaboration with museum professionals was crucial to our own way of working, not in the form of a typical relationship between clients and designers, but as co-researchers jointly trying to understand the opportunities and challenges posed by visualisation to the field of digital humanities.

In our iterative process, we increasingly customised conventional timeline formats and experimented with alternative ways of representing events in time, specifically with regards to uncertainties in dating and large humanities datasets. While curators were generally enthusiastic about our prototypes and found them to be useful, this departure from established graphical paradigms also caused some difficulties and required us to provide additional explanation. At times, there were insecurities about how to read our diagrams, what exactly the position or size of a graphical mark represents, and what an apparent pattern actually says about the underlying dataset. This forced us to be explicit about our designs and reasoning, just like our predecessors when they created chronographics for the first time.

We, as designers, had to learn to be critical about our motivations. Faced with problems and inconsistencies in the representation of data, we are trained to find a solution to make the problems disappear. Museum curators are similarly inclined to present a coherent view of history to the public and are often forced to display an unrealistic level of certainty about the contents of their collections.

Designers and curators are used to acting as 'transformers,' striving to "put the expert's message in a form the reader can understand" (Macdonald-Ross & Waller, 1998). By collaborating early on in the design process and jointly uncovering the complexities of humanities data and visualisation design, we were able to use errors and inconsistencies as a point of departure for critical discourse rather than moving them out of sight for the sake of a universally understandable message.

Through our visualisations, we reveal issues that should not be ignored and, at the same time, we provide means for communicating and tackling them. Our work emphasises that there can be no transparent or 'direct' (Manovich, 2011) representation; all representations are based on selection, abstraction, pragmatism, and choice, not on simple matching to an external source (see Boyd Davis, 2007). By working closely with the 'owners' of the source material, we have been able to fine-tune our representations to key issues emerging from partial, incomplete, contingent — in other words, real — data. Museums and archives are aware of the fact that their collections are biased, but instead of having to surrender to this reality, curators and archivists are given an opportunity to confront and reflect on the collecting history and cataloguing practices of their institutions.

As designers working on digital humanities projects, we have to learn to account for irregularities, inconsistencies, and complexities in visualisations even if this means compromising on tidiness, cleanliness, and simplicity — attributes often held up as watchwords of design. Where information design aims to maximise usability and clarity, in the humanities we have to maximise honesty and transparency in order to do justice to the subtlety, imprecision, and messiness of history and historiography.

Data in the humanities has been re-characterised by Drucker (2011) as 'capta': subjective, flawed, incomplete, inconsistent and uncertain (though it could well be argued that data in the sciences has, in fact, many of the same features). Visualisations are not only representations of a dataset, but also always an image of the structure it is stored in, the authorities that produced it, and the motivations and beliefs that governed those authorities. As designers, we need to collaborate with humanities scholars in order not to mistake discoveries for errors and make the knowledge that we may find during the creative process available. We have said that chronographics both require and enable critical thinking. Chronographic visualisations still have the advantages claimed for them at their origins in the eighteenth century: comprehensive overview, ready apprehension, and the revealing of patterns, contemporaneities, dependencies, overlaps, outliers and other features that would otherwise be hard to discern. Far from mechanistically simplifying history, when treated with sufficient critical subtlety, they also have the potential to foreground the 'thick' (Geertz, 1973) layers of curatorial and historiographical practice that surround the objects, events, and records of the past.

Acknowledgements

We gratefully acknowledge invaluable advice from Prof. Anthony Grafton, Dr. Mary Pedley, and Prof. Michael Twyman. We are indebted to Princeton University Department of Rare Books and Special Collections, Chetham's Library Manchester, Bibliothèque Municipale Dijon, John Rylands Library University of Manchester, Wren Library Trinity College Cambridge, and to all the curators we have worked with, in particular Dr. Lucy Walker. Florian Kräutli's research is funded by an EPSRC CASE award EP/J502169/1 and by System Simulation Ltd.

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