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On the Cultural History of Time Series Graphs

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On the Cultural History of Time Series Graphs

Abstracts

Taking the insights from *diagrammatology* – rooting in German media and culture studies (*Medienkulturwissenschaft*) and semiology – as background, this essay seeks to answer the question of how the history of the visual representation of temporal processes can be captured, and how the emergence of the statistical time series graph has influenced our ideas about time, history, and stories. To this end, I will provide a cultural-historical overview that, beyond shedding light on the interrelationships between different discourses (e. g., economy, statistics, science, literature), can contribute to a critical examination of perhaps the most widespread type of diagram used today. This overview can be understood more as a proposal for discussion, aimed at encouraging methodological and historical reflections on digital humanities practices, rather than as a presentation of a closed topic.

Ausgehend von den Erkenntnissen der *Diagrammatologie*, die ihre Wurzeln in der deutschsprachigen *Medienkulturwissenschaft* und der Semiotik hat, soll in diesem Aufsatz die Frage beantwortet werden, wie die Geschichte der visuellen Darstellung zeitlicher Prozesse erfasst werden kann und wie die Entstehung der statistischen Darstellung von Zeitreihen unsere Vorstellungen von Zeit, Geschichte und Narrativen beeinflusst hat. Zu diesem Zweck gebe ich einen kulturgeschichtlichen Überblick, der nicht nur die Zusammenhänge zwischen verschiedenen Diskursen (z. B. Wirtschaft, Statistik, Wissenschaft, Literatur) beleuchtet, sondern auch zu einer kritischen Auseinandersetzung mit dem heute vielleicht am weitesten verbreiteten Diagrammtyp beitragen kann. Dieser Überblick ist eher als Diskussionsvorschlag zu verstehen, der zu methodischen und historischen Reflexionen über die Praktiken der digitalen Geisteswissenschaften anregen soll, denn als Präsentation eines in sich geschlossenen Themengebiets.

1. Introduction

»If there is one feature that immediately distinguishes the digital humanities (DH) from the ›other‹ humanities, data visualization has to be it.«[1] For this reason it is important to analyse the different ways of data visualisation in order to better understand the discipline. Although such reflections have been made recently, it is worthwhile to complement them with insights from other fields that describe diagrams from an epistemological, semiological and media-theoretical perspective. These different approaches can together outline the *diagrammatology* [2] of data visualisation; within which I adress the question of the techniques of representation of time.

According to George Lakoff's influential theory, we understand and express temporal events as spatial movements or pathways in metaphorical constructions (»the time has *come*« or »I will be there *in* time«). He emphasises that this kind of understanding is a fundamental and general cognitive operation motivated by our »biological knowledge« of the world.[3] Ludwig Wittgenstein points out that, beyond the everyday experience of temporality, our conceptions of time itself are organised by spatial metaphors, especially the metaphor of »time as a river« (cf. »timestream«), which enables us to speak of time as a material being.[4] The general structure inherent in this metaphor is also highlighted by W. J. T. Mitchell, who identifies the line of straight progression as a prerequisite for our thinking about time: »The fact is that spatial form is the perceptual basis of our notion of time, that we literally cannot ›tell time‹ without the mediation of space. All our temporal language is contaminated with spatial imagery: we speak of ›long‹ and ›short‹ times, of ›intervals‹ (literally, ›spaces between‹), of ›before‹ and ›after‹ – all implicit metaphors which depend upon a mental picture of time as a linear continuum.«[5] What all these theories have in common, despite their remarkable differences, is that they consider the mental operations of conceiving temporality based on the physical world to be anthropological constants. However, it is also worth asking how these metaphors and mental operations develop *over time*: how can the line representing time be characterised and how do these characteristics evolve historically – in other words, how do the various schemas materialise under different conditions?

These conditions include the different kinds of non-discursive, graphical depictions (known as diagrams) used by a given culture, whose changes not only affect the range of things that can be represented and the way they are represented, but also have a major conceptual impact. Indeed, diagrams are responsible for making abstract entities – above all, time – spatialised,

[1] Moretti / Sobchuk 2019, p. 86.
[2] Cf. Krämer 2009; Stjernfelt 2007.
[3] Lakoff 1993.
[4] Wittgenstein 1989.
[5] Mitchell 1980, p. 542.

conceivable, and manageable.[6] Yet, surprisingly little is said in cultural studies about this schema-forming role of diagrams; they are instead discussed as »drivers of reasoning« or as practical »laboratories of thinking«,[7] and their wider impact on perception and cognition is almost always thematised in socio-critical discourse that rarely questions the practical / technical preconditions of knowledge production and transmission.[8] Perhaps it is precisely because of the non-discursive nature of diagrams, which has long precluded their more detailed examination in the discourse of language-bound humanities, and which has made them accessible only in a linguistic-semiotic way.[9]

In the following, I will illustrate the impact of diagrammatic representations on the history of ideas through an example. My hypothesis is that the statistical, time-series graphs that emerged in the 18th century *gave shape* to modernity's view of time, and to the structure of history and stories. I will develop this thesis in four steps on topics related to diagrams, narratives and temporality. First, I will sketch the central elements of modernity's concept of time and its relationship to statistical diagrams; second, I will outline the scientific and cultural-historical context of the earliest time series graphs; third, I will present preceding concepts and representations of temporality; and finally, I will discuss how the changing perception of time is reflected in the narrative structure of the literary works of the period. These steps are not so much a detailed historical analysis as a juxtaposition of different fields and historical moments, which I hope will help to develop a reflective attitude towards contemporary practices. This seems important because today's (digital) humanities research increasingly uses time series graphs to represent historical change, or even to draw conclusions from them – while at the same time there are also increasing criticisms of the limitation of such representations and the related concept of time. In this complex situation characterised both by the proliferation of graphs and their critique, it seems worthwhile to undertake a historical investigation – exactly in order to better understand our scholarship and its cultural context.

2. Modernity's concept of time and time series graphs

With the emergence of time series graphs, the time axis[10] is no longer a linear line in itself, but one of a coordinate system (traditionally the abscissa, or ›x‹-axis), where the other axis is used to measure another, optional quantity. The temporal processes are then represented as lines drawn in this system, the properties of which can now be described quantitatively and against the background of two-dimensional space (e. g. the degree of slope). These lines are produced by connecting individual data points or (with the later development of statistics) as regression lines fitted to these points. This change in the cultural techniques[11] of representation of time may seem trivial, but its impact on the way we think about events in time is nonetheless significant; as it is also worth bearing in mind that this is a relatively recent development – until the end of the 18th century, such representations and graphical interpretations of everyday phenomena did not exist, except in isolated examples.[12] Of course, the layout of graphs is equally influenced by metaphors rooted in our ›biological knowledge‹, such as MORE IS UP and LESS IS DOWN, but these metaphors have also been shaped by the appearance of graphs – just take the examples by Lakoff, which happen to refer to concrete time series graphs: »Stocks skyrocketed«, »The market plummeted.«[13] Today, we cannot even imagine quantitative changes in processes without graphs appearing before our eyes.

Modernity's concept of time – beyond the fact that its own self-descriptions also refer to temporality[14] – can best be grasped in terms of linearity, continuity, progress, acceleration, historicity, and the notion of open future[15]. This concept is based on that ›past‹ and ›future‹ (which are established as terms only in the 18th century) are essentially different from ›present‹, whereas these different points in time are also in a continuous relationship. In this way, the future can be planned and shaped by taking into account experiences of the past: a way of thinking that Hans Ulrich Gumbrecht calls the »chronotope of historical consciousness«.[16] Accordingly, the practical application of time series graphs is often focused on prognosis, as the patterns that emerge in them appear to be transposable into the future. Such uses of graphs range from weather forecasting and climate

[6] Krämer 2009. For the operative character of diagrams and the notion of »diagrammatic reasoning«, see: Peirce Edition Project (eds.) 1998, pp. 212–213.
[7] For these Peircian concepts, see: Stjernfelt 2007.
[8] D'Ignazio / Klein 2020; Drucker 2014.
[9] As in Wilkinson 2005.
[10] The term ›time axis‹ refers to the tradition of representing time on the x-axis of the Cartesian coordinate system. Its origins can be traced back to William Playfair (whose work is described in detail below), who produced the first histograms as an idealised form of coin stacks: the variation of the stacks on a table could show financial trends or relations. In this sense, time is the surface on which ›coins‹ or other dependent variables can be placed. This tradition is strengthened by mechanical records such as those that automatically record changes for example in pressure or bodily functions (muscular motion, blood pressure, etc.) We can define all media as methods of ›time axis manipulation‹ or spatialization of time (see Krämer 2006, pp. 93–109), which makes graphs *abstract media*, without which we could not talk about ›time axis‹ at all.
[11] Cultural techniques are habitualized bodily practices through which things and symbols become manageable, and which thus enable the externalised, operative processing and creation of inner thoughts. See Krämer / Bredekamp 2013.
[12] Funkhouser 1937; Krausse 1998.
[13] Lakoff 1993, p. 12.
[14] Koselleck 1979.
[15] About the concept, see Rammstedt 1975.
[16] Gumbrecht 2014, p. 32.

modelling to the study of the spread of epidemics and the identification of economic regularities. Observable patterns can show two types of regularity: they can be based on unidirectional trends or cyclicality. This duality – described by Stephen Gould as the duality of the time's arrow and the time's cycle[17] – is unified in all media that represent time, insofar as they simultaneously enforce the logic of circular recurrence and progression, as in the case of calendars for example.[18] Yet the early time series graphs promoted the notion of a linearly progressing, evolving time, perhaps in the absence of sufficient amount of data to chart cyclical changes.

On the other hand, this very arrangement of past, present and future (the difference *and* connection of points in time) has in most cases contributed to the very notion of continuous development and acceleration. Hartmut Rosa argues that this is not simply a consequence, but as much a precondition of technological and industrial development: there was already a need for accelerated life, since social stability with population growth seemed to be guaranteed only by ever faster development – a need that was only subsequently realised and strengthened by new technologies.[19] The same interaction can be assumed between the modernist conception of time and capitalist production, insofar as the requirement of constant profit maximization and »the conception of the progress of civilization as the unlimited increase of objects produced for sale«[20] both presuppose *and* deepen the notion of an ever changing but malleable time. The qualitative and quantitative difference between points in time, the processual nature of the changes, and the calculations for the future can be expressed in the same graphic form: the trend curve of the time series graph. This curve *models, creates and shapes* the new modernist concept of temporality. No wonder that the practical use of such representations is also fundamental to the modern economy and industry: analyses and forecasts based on graphs organise the functioning of the capitalist market.

3. William Playfair and the statistical graph

The first statistical graphs can also be found in an economic work, William Playfair's *The Commercial and Political Atlas*, published in 1786.[21] In his preface, Playfair himself emphasises the importance of ›giving form‹, a detail that could be applied more generally to the various techniques of graphic representation of temporality: »The giving form and shape, to what otherwise would only have been an abstract idea, has, in many cases, been attended with much advantage; it has often rendered easy and accurate a conception that was in itself imperfect, and acquired with difficulty.«[22] Figure 1 shows changes in interest rates on the British public debt, and Figure 2 shows British military expenditure in the 18th century. These, along with 42 others, are the first modern statistical line charts in Western cultural history – although Playfair also cites Joseph Priestley and his *Chart of Biography* as an important precursor. But that one simply shows the time and duration of the lives of famous people divided into separate groups (artists, scientists, politicians, soldiers) parallel to the timeline, not the relationship between time and an independent variable – i. e. the lines have no slope, only length (Figure 3). However, a graph-like reading is already implied by this figure, and it is this approach that allows the interpretation of general historical movements – if not the individual lines, then their combined presence carries quantitative information that varies over time. After all, Priestley argues that denser sections indicate a more advanced, innovative era than sparser ones, and vice versa: »By the several void spaces between […] groups of great men, we have a clear idea of the great revolutions of all kinds of science, from the very origin of it; so that the thin and void places in the chart are, in fact, no less instructive than the most crowded, in giving us an idea of the great interruptions of science, and the intervals at which it hath flourished […]. We see no void spaces in the division of Statesmen, Heroes, and Politicians. The world hath never wanted competitors for empire and power, and least of all in those periods in which the sciences and the arts have been the most neglected.«[23]

[17] Gould 1987.
[18] Macho 2000.
[19] Rosa 2015; Koselleck 1979.
[20] Buck-Morrs 1995, p. 456.
[21] The term atlas highlights the common nature of cartography and statistical diagrams, in that both arrange and link graphical elements on a grid of planar surfaces, and the fact that the tradition of cartography has become mobilised in the creation of statistical graphs. Both the English term chart and the French carte figurative are derived from the Latin word carta meaning map.
[22] Playfair 1801.
[23] Quoted by Rosenberg / Grafton 2010, p. 125. This pioneering book is an important source for the history of representations of time; also the present paper takes its insights further in the context of wider cultural history.

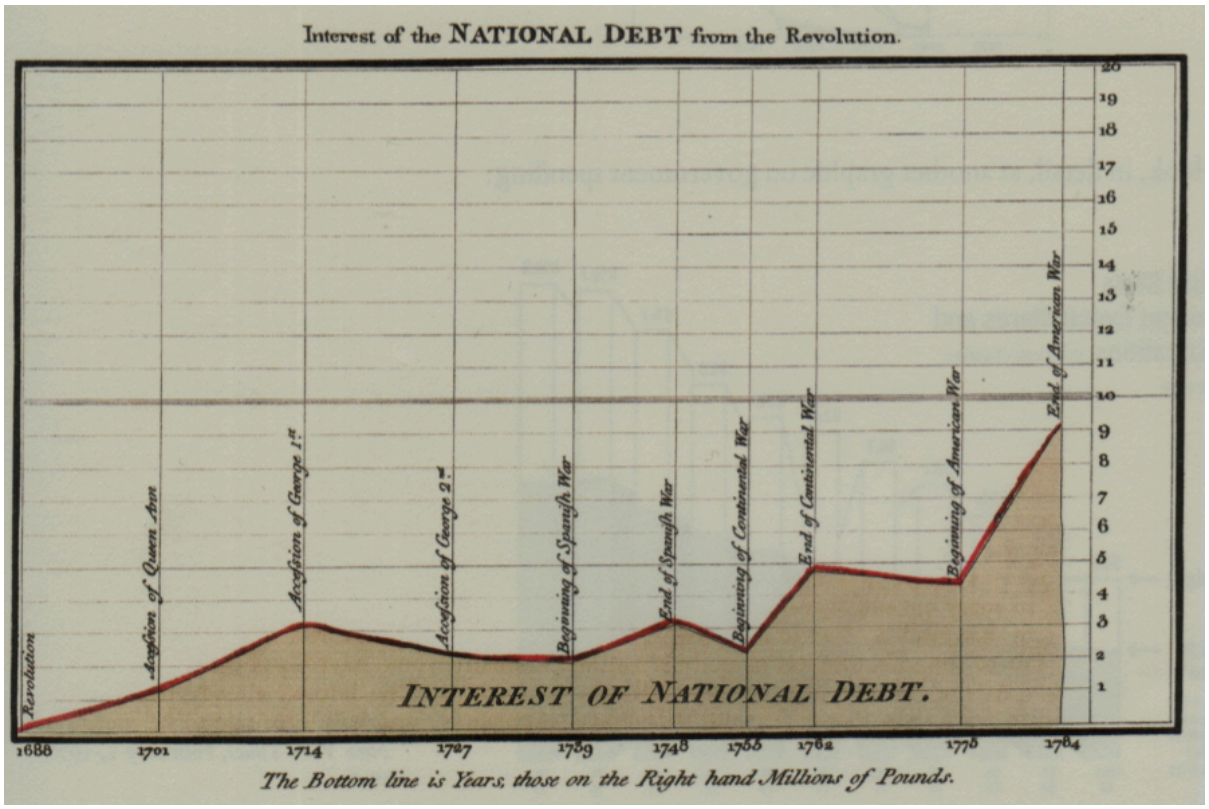


Fig. 1: William Playfair: *Interest of National Debt from the Revolution* (1786) [Graphic from: Playfair 1801 [1786]]

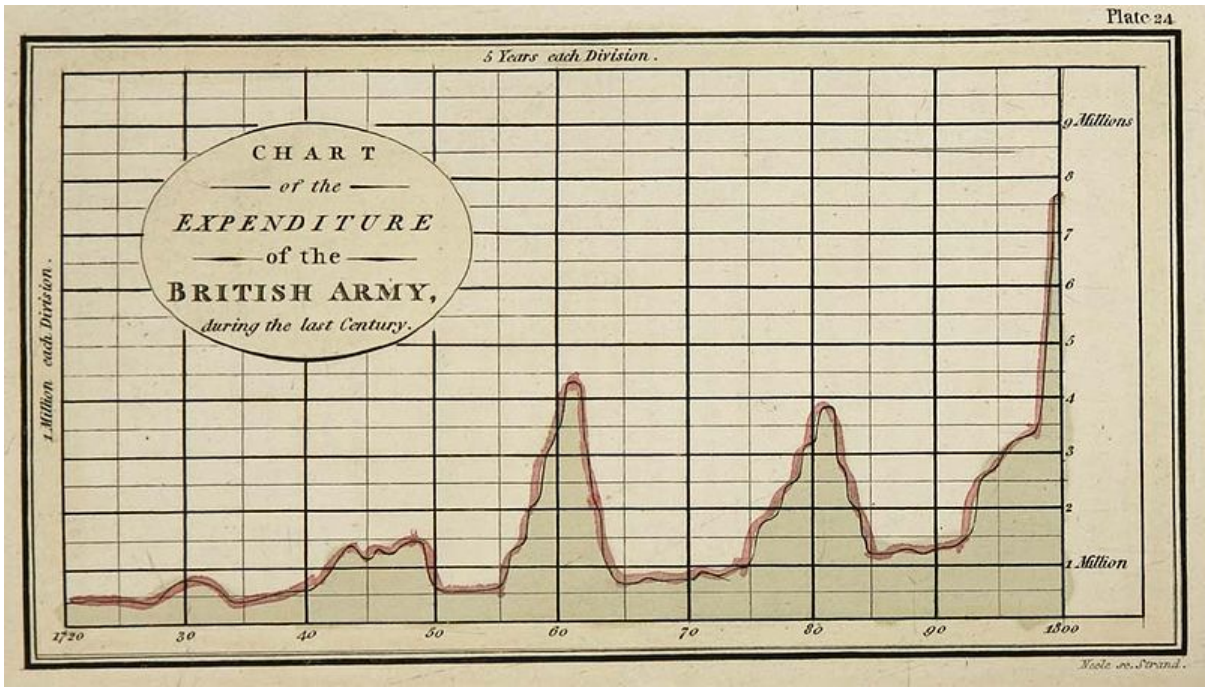


Fig. 2: William Playfair: Chart of the Expenditure of the British Army (1801 [1786]) [Graphic from: Playfair 1801 [1786]]

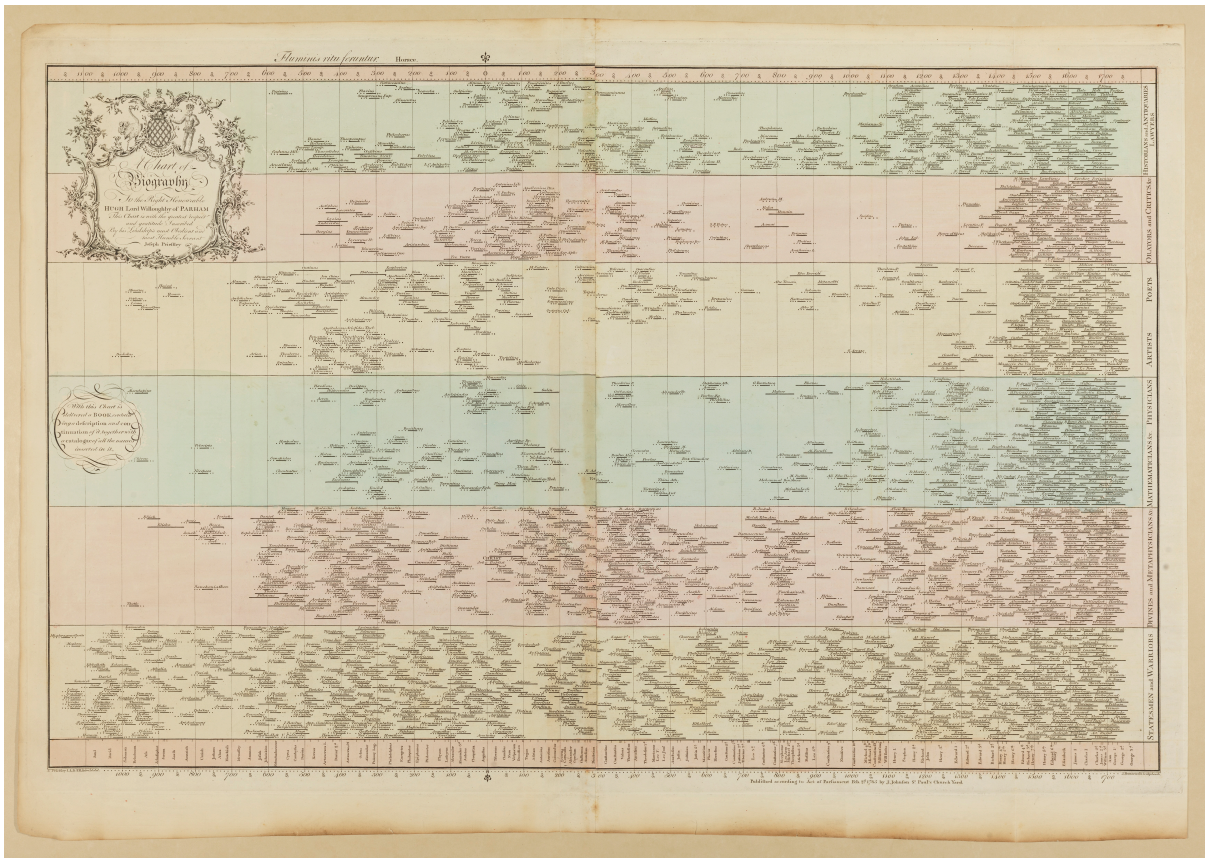


Fig. 3: Joseph Priestley, *Chart of Biography*, London 1765. [Image Source: Library Company of Philadelphi a, also used in: University of Oregon InfoGraphics Lab: Chronographics. The Time Charts of Joseph Priestley]

Even if he himself was forgotten during the evolution of statistics in the 19th century, Playfair's method, what he calls »lineal arithmetic«[24], was revolutionary in the field of data visualisation. It is hard to believe that, before the *Atlas*, such a representation of historical, social and economic processes was unknown, especially since Playfair's graphs did not cause any major difficulties for his contemporaries, i. e. they did not require the development of radically new interpretative skills. More broadly, similar mappings have existed in Western culture and science since the 17th century – at the latest since the appearance of Descartes' coordinate system – but in the field of physics and not for describing specific events or processes, but for describing the general movements of bodies. According to Albert Biderman, these diagrams, which were intended to capture the laws of physics (e. g. in the case of Newton), were not the forerunners of statistical graphs, but rather obstacles to their development, in that they did not allow for a similar representation of individual, empirical cases. Furthermore

> »neither the Cartesian system, nor any geometry that did not exist before Euclid, was at all needed for any of Playfair's forms. Little geometry was needed for any of the few elaborations of, or additions to, them that saw much useful service in the statistical graphic repertoire for almost a century after Playfair's first work [...] Formal mathematical geometry seems to me to have been a downright obstacle to the development and diffusion of most of the graphics for statistics.«[25]

Biderman distinguishes two traditions of natural science in the modern era: one that seeks to bring order to available observations (*empiricism*); and one that seeks to unravel the structure of *The Great Design* (*Cartesianism*). While Descartes and the early modern rationalists fall into the latter group, Playfair and his followers tend to follow the former, Hobbesian, paradigm.[26] Moreover, a very technical circumstance of the era made it difficult to produce statistical graphs, namely the difficulty of printing. As Ian Spence and Howard Wainer point out, copperplate engraving required advanced skills, which most scientists in the 18th century did not possess (unlike the polyhistor, ›craftsman‹ thinkers of earlier eras), and it allowed only a few prints to be made before the copper plate became unusable.[27] This media-historical context is fundamental to the study of diagrammatic

[24] Playfair 1801, XI.
[25] Biderman 1990, p. 11.
[26] Biderman 1990, pp. 14–15.
[27] Spence / Wainer 2017.

representations: from the 18th century, it became increasingly easy to produce and distribute graphs in large quantities; this has continued to the present day, where data visualisation also could not play such a central role without the spread of technological developments.

The real predecessors of statistical graphs are earlier techniques of mechanical records and data collection. Also the fact that, as a young man, Playfair worked for James Watt's company, where an automatic machine recorded the pressure changes in steam engines, and the diagrams drawn in this way helped to determine the optimum level of steam compression, may shed light on the importance of mechanical records[28] – whose development in the 19th century is an important part of the media history of time series graphs (see e. g. Figure 4). More influential in this history, however, are the 18th century practices of data collection and visualisation, especially the ones showing changes in temperature and air pressure. One of their earliest antecedents is the *History of Weather* by Robert Plot (Figure 5), which shows the daily values of the change in air pressure in 1684 on a single graph. This was accompanied by the creation of different meteorological metrics (Fahrenheit: 1720, Réaumur: 1730, Celsius: 1740), which also highlights the close link between measurability and data visualisation, since an accepted scale is needed to create the vertical axis, representing an independent variable. If we see modernity as a story of the standardisation of measures,[29] it is worth including statistical plots in it – as a counterpart of another device of the industrial capitalism that measures and divides time into smaller units, namely the clock. In any case, the daily reading of the temperature and the plotting of changes, can be seen as a precursor to modern data visualisation. This is also true in a very concrete sense: it is again a phenomenon that appeared in Playfair's personal life – he was encouraged by his brother, the mathematician John Playfair, to make similar weather charts in his youth.[30]

The different techniques of charting changes in pressure (in the steam engine in the case of Watt, or barometric in the case of meteorology) have thus provided a model for *lineal arithmetic*. Its statistical counterpart was *political arithmetic*, which described the governmental and economic operation of data collection in England from the 17th to the 18th century.[31] Political arithmetic as a field referred to wide ranges of practices from censuses to quantitative analysis of taxes and healthcare, and it sought to create economic equivalents of Newton's laws – but still with mere listings of data, rarely in tabular form, but without any other graphical features. Playfair combined these calculations with earlier techniques of data visualisation to create the prototypes of graphs we know today.

[28] Biderman 1990, pp. 14–15.
[29] See Latour 1986.
[30] Spence / Wainer 2017.
[31] Hoppit 1996; Sepkoski 2018.

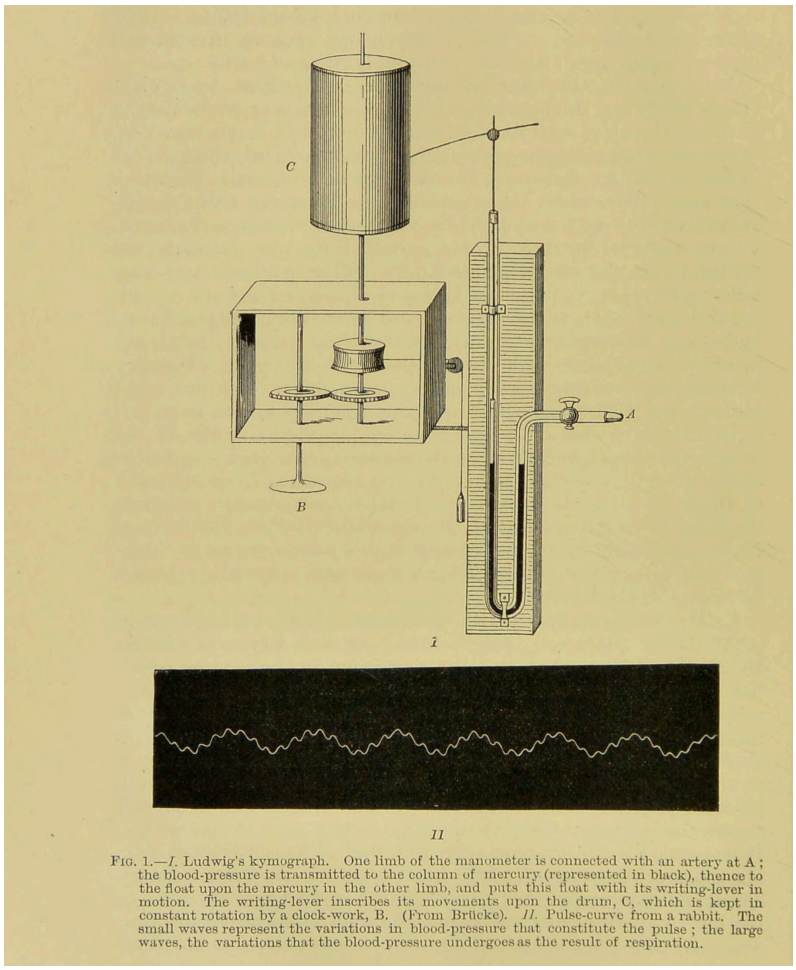


FIG. 1.—*I.* Ludwig's kymograph. One limb of the manometer is connected with an artery at A; the blood-pressure is transmitted to the column of mercury (represented in black), thence to the float upon the mercury in the other limb, and puts this float with its writing-lever in motion. The writing-lever inscribes its movements upon the drum, C, which is kept in constant rotation by a clock-work, B. (From Brücke). *II.* Pulse-curve from a rabbit. The small waves represent the variations in blood-pressure that constitute the pulse; the large waves, the variations that the blood-pressure undergoes as the result of respiration.

Fig. 4: Karl Ludwig's *kymograph* – a machine for automatic recording of blood pressure. [Graphic from: Verworn 1899, fig. 1, p. 24; Source: Wellcome Collection]

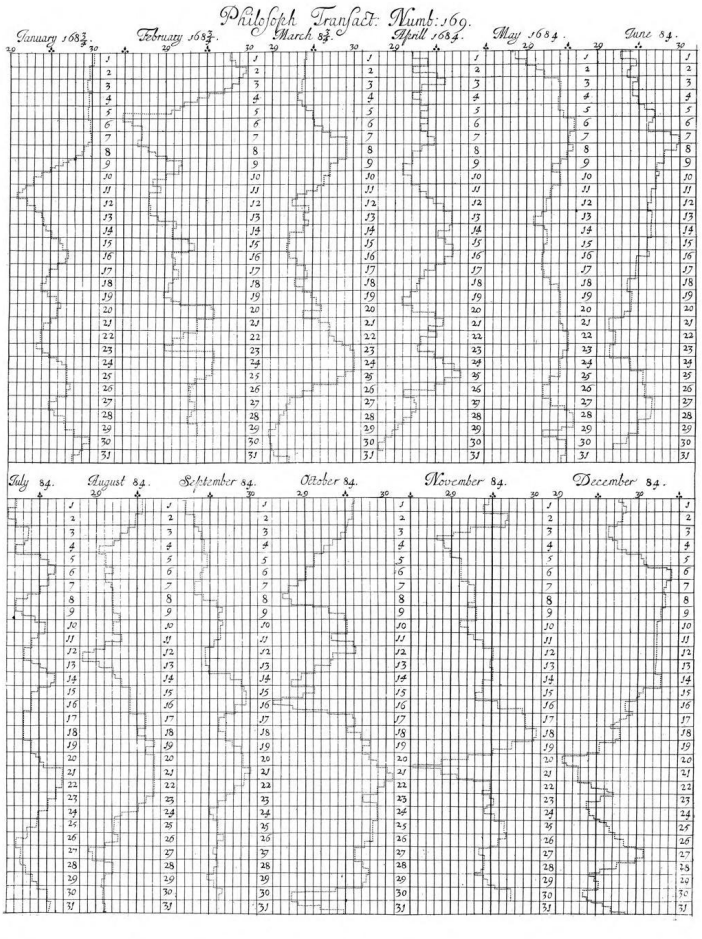


Fig. 5: Robert Plot's *History of the Weather* [Graphic from: Plot 1753, p. 43]

4. Versions of ›developement‹ and ›narrativity‹

The question arises as to what kind of visual representation of temporal processes was prevalent before statistical graphs and what effect that had on individual and social imagination. The most common forms were the tables or lists of *annales* (a layout inspired by the calendar), which relied on the parallel presentation of events and a less strict arrangement of data.[32] The primary purpose of such lists or tables was to harmonise different chronologies. The greatest influence on this form came from the third- to fourth-century theologian Eusebius of Caesarea, whose Chronicle juxtaposed the histories of Christianity and other religions on a single timeline. Simultaneous events were indeed placed side by side in the table, while if an event had no contemporary counterpart in other chronologies, the relevant parts of the parallel columns were left blank. (Figure 6) This arrangement, highlighting simultaneity, does not so much link individual events into a story as keep them in discrete, sequential units. The concept of temporality in historical thinking was motivated by this form – its influence can be seen even in early 18th-century ideas about social development. Such is the case with the famous work of Anne Robert Jacques Turgot from 1750 (*A Philosophical Review of the Successive Advances of the Human Mind*), which, although anticipates the concepts of generally accelerated development from the end of the 18th century, still places great emphasis on the different evolution of individual civilisations, and on the ›dead ends‹ of some of them. In other words, he sees development as a rather fragmented process, with backward steps and parallelisms, modelled on the growth of plants: just as a plant produces many buds at once until one flowers, so develops human history.[33]

However, this concept was replaced in the 19th century by that of linear acceleration, which refers to quantifiable change, and which compares and relates discrete data points in the same way as trend curves connect them in time series graphs. »The question of acceleration is embedded in the general question of what historical time is. […] From a theoretical perspective,

[32] Boyd Davis 2017; Rosenberg / Grafton 2010.
[33] This idea recalls rather Darwin's coral-like diagram of evolution, see Bredekamp 2005.

there can also be progress when it takes a regular path, so that the mere speed of change or improvement provides no additional indication that anything is changing at all in a progressive way [...]. Only when rates, which are measured in the same intervals of natural chronology, increase geometrically and no longer arithmetically can something accordingly be registered as acceleration.«[34] – writes Reinhart Koselleck, also defining the essence of modernity's relationship to time in terms of measurability. »It qualifies the ›progress of history‹, an expression that became sayable only after 1800.«[35]

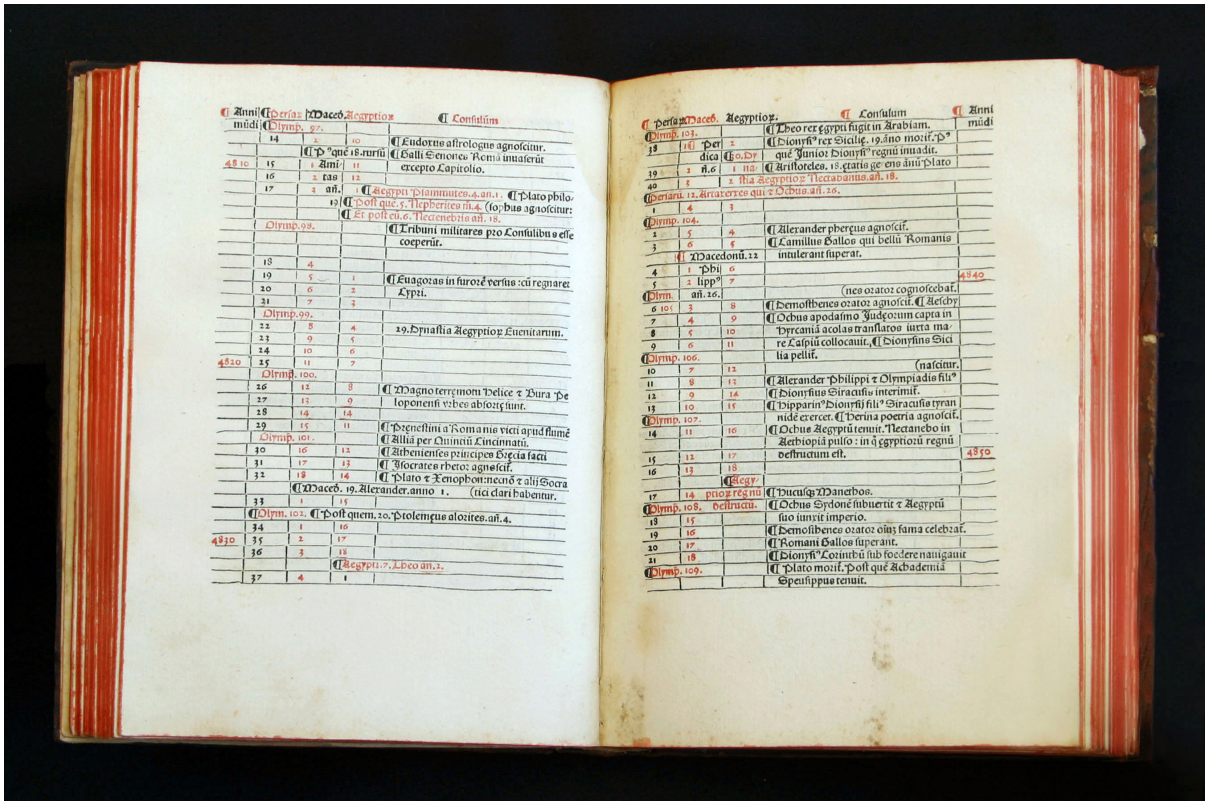


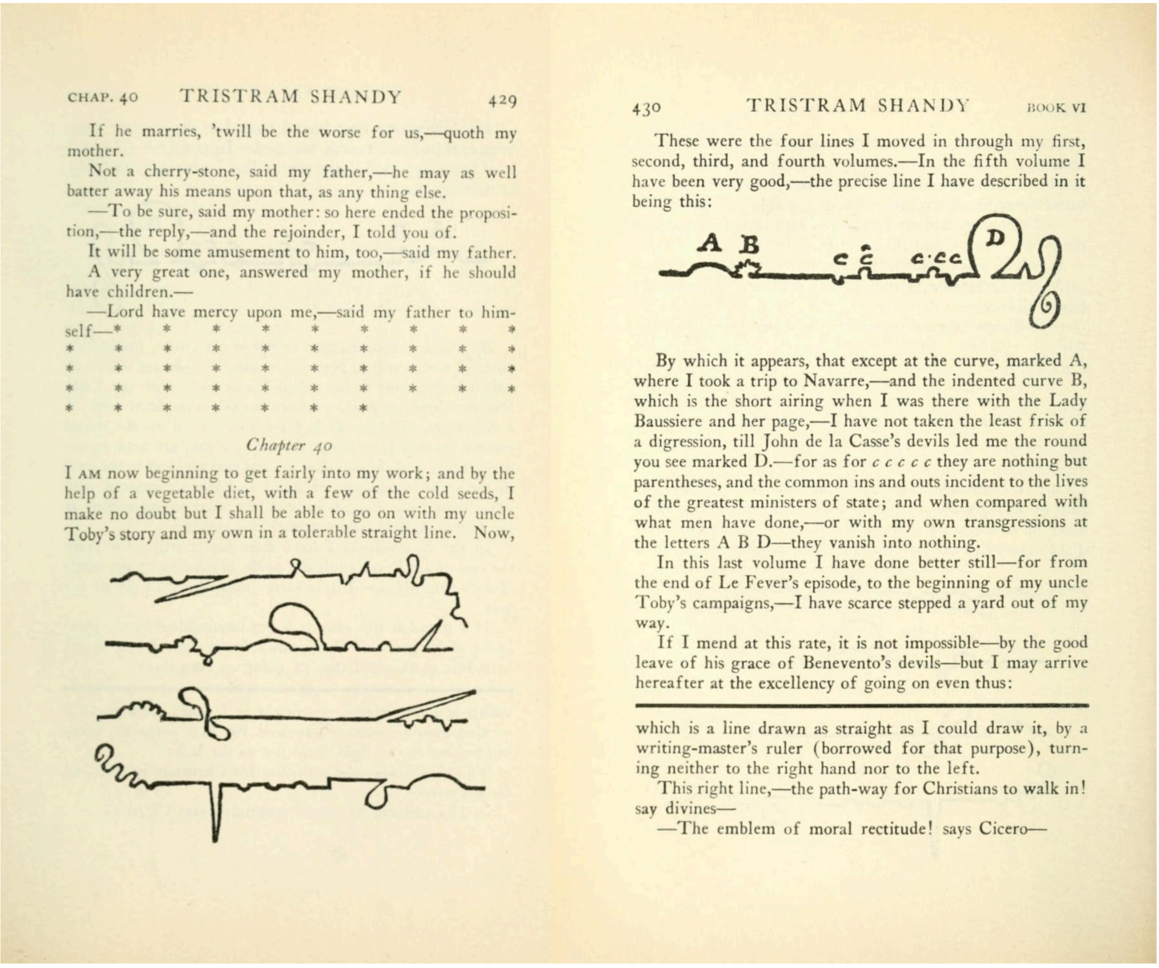
Fig. 6: Eusebius, of Caesarea, Bishop of Caesarea, Chronicon, edition by Erhard Ratdolt 1483. [Source: Special Collections & Archives Research Center, accessed 13.02.2024, online]

Wolfgang Ernst sees the predecessors of computational data processing in the chronologies of medieval *annales*, which, as he notes, differ in many ways from historical narratives: they do not establish causal relationships, they do not organise elements in a foreground-background manner, i. e. they do not interpret historical processes in advance in the way narratives do. »Is there really something like an anthropological need to link unconnected, contingent experience into narrative wholes?«, asks Ernst, to which he clearly answers »no«. On the contrary, he says »the discrete counting of data ›factualism‹, according to Gérard Genette, instead of its narration, resembles a diagram rather than a picture and requires anonymous pattern recognition instead of the personal narrator.«[36] This analysis is certainly noteworthy, as it asserts the importance of diagrammatic operations within historiography (and even sees them as a more attractive, freer concept than narrative history). However, this separation (diagrams vs. narratives) does not work in all cases: statistical graphs could be described as a unification of previous juxtapositions and pluralities, and, in the same way that a story necessarily transforms a series of events into a causal chain, time series graphs also connect data points, fix their relationships and make them interpretable in terms of a linear process. From this point of view, the relation of graphs to narratives seems to be at least as close as to other kinds of representations – as is indicated by the term ›plot‹ (or in German the common root of ›zählen‹ (to count) and ›erzählen‹ (to narrate)[37]).

[34] Koselleck 2009, p. 124.
[35] Koselleck 2009.
[36] Ernst 2012, p. 151.
[37] Ernst 2012.

5. Graphs and literature / (computational) literary studies

But it is not only their etymology, but also their common history that brings these concepts (graphs and narrative) closer together. Whereas philosophical works like Turgot's see development as unfolding only in huge and abstract civilizational steps, modernist conceptions also trace everyday, empirical events along a single line: in addition to history, we increasingly structure our stories according to this line. This is true of the story of an individual life that is elaborated less against the background of a journey and more against one of personal *development* (*Bildung*) and the desire for a career that is *to rise*; and often also of the literary genres that depict such lives and desires. Mikhail Bakhtyin points out that the characters of ancient stories and later adventure novels (right up to the 18th century) are unchanging personalities, their actions and the plot itself being reducible to »spatial movement« (escape, shipwreck, etc.); the specificity of heroes is precisely their ability to maintain a stable identity throughout their adventures.[38] This spatial succession can also be seen in the dramaturgical structure of pieces of literature: in the *Poetics*, Aristotle depicts the individual parts as their mere succession, not progression along an arc of development, just as the terms of ›turn‹ or ›realization‹ is not presented in their processual character, but as »transformation«.[39] (Laurence Sterne parodies this idea in *Tristram Shandy* in the 1760s by inserting loops and irregular fractures into the straight line of the story – as he shows this also visually: Figure 7). In contrast, Gustav Freytag, in his 1863 book *Die Technik des Dramas*, already illustrates the development of the plot as a »pyramid«, i. e. a graph, which he divides into the following sections: introduction (a), rise (b), climax (c), return/fall (d), catastrophe/resolution (e) (Figure 8). From the late 18th century onwards, literary works increasingly rely on a graph-based idea of storytelling, both in their subject and structure. The plot is the result of connecting points at different levels (mostly in terms of intensity), and the writer's main task becomes the effective creation of the plot arc, as it is for the creators of Hollywood films and contemporary series.



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If he marries, 'twill be the worse for us,—quoth my mother.

Not a cherry-stone, said my father,—he may as well batter away his means upon that, as any thing else.

—To be sure, said my mother: so here ended the proposition,—the reply,—and the rejoinder, I told you of.

It will be some amusement to him, too,—said my father.

A very great one, answered my mother, if he should have children.—

—Lord have mercy upon me,—said my father to himself—* * * * * * * * *
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Chapter 40

I AM now beginning to get fairly into my work; and by the help of a vegetable diet, with a few of the cold seeds, I make no doubt but I shall be able to go on with my uncle Toby's story and my own in a tolerable straight line. Now,

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These were the four lines I moved in through my first, second, third, and fourth volumes.—In the fifth volume I have been very good,—the precise line I have described in it being this:

By which it appears, that except at the curve, marked A, where I took a trip to Navarre,—and the indented curve B, which is the short airing when I was there with the Lady Baussiere and her page,—I have not taken the least frisk of a digression, till John de la Casse's devils led me the round you see marked D.—for as for *c c c c c* they are nothing but parentheses, and the common ins and outs incident to the lives of the greatest ministers of state; and when compared with what men have done,—or with my own transgressions at the letters A B D—they vanish into nothing.

In this last volume I have done better still—for from the end of Le Fever's episode, to the beginning of my uncle Toby's campaigns,—I have scarce stepped a yard out of my way.

If I mend at this rate, it is not impossible—by the good leave of his grace of Benevento's devils—but I may arrive hereafter at the excellency of going on even thus:

which is a line drawn as straight as I could draw it, by a writing-master's ruler (borrowed for that purpose), turning neither to the right hand nor to the left.

This right line,—the path-way for Christians to walk in! say divines—

—The emblem of moral rectitude! says Cicero—

Fig. 7: Two pages from Laurence Sterne, *The Life and Opinions of Tristram Shandy, Gentleman*, New York 19XX [1759–1767], pp. 429–430. [online]

[38] Bakhtin 1981, pp. 84–100.
[39] Aristotle 2012.

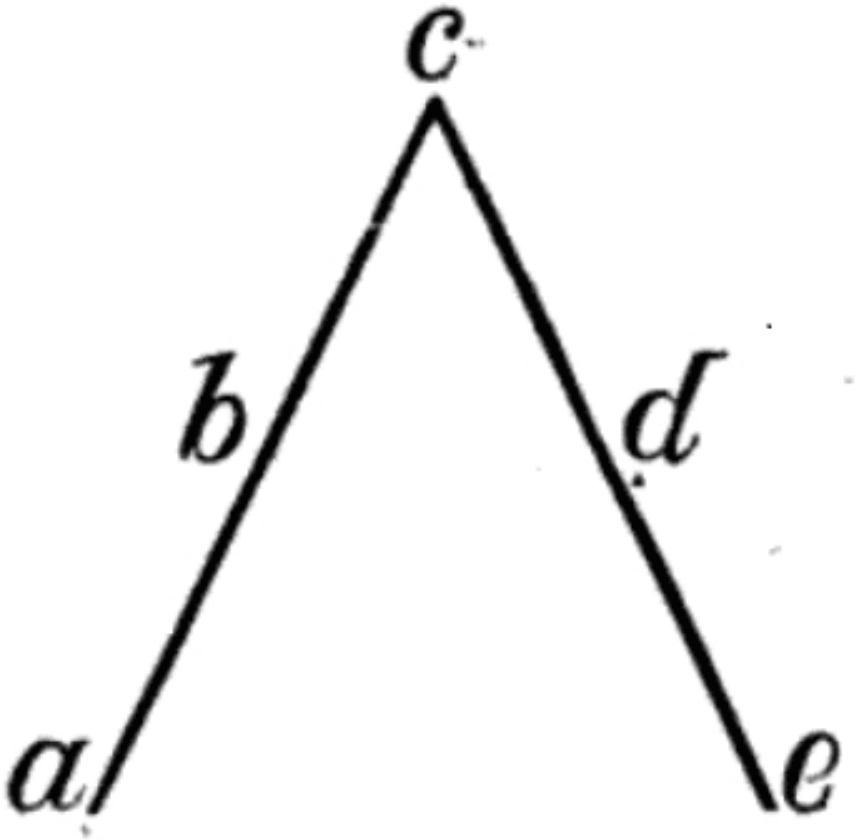

Fig. 8: Freytag-pyramid, first publication: Gustav Freytag, *Die Technik des Dramas*, Leipzig 1863, p. 102.

The primary literary genre of such storytelling and such a concept of life is the *Bildungsroman*, which developed at the turn of the 19th century, and which placed – for the first time in the history of literature – youth at the center of the plot. In Stendhal's *Le Rouge et le Noir* (first published in 1830), Julien Sorel's goal is gradual social advancement, while Goethe's[40] Wilhelm in *Wilhelm Meisters Lehrjahre* (first published in 1795/96) succeeds in integrating into society by connecting together and unifying his experiences. The Bildungsroman seeks to combine elements of individual life in close causal relation to each other and to embed them in the wider social reality. Franco Moretti's book on the genre also highlights this: »symbolic construction always ›connects‹ the ›individual moments‹ of a text with all the others: they are thus ›preserved‹ in their singularity, while simultaneously made ›meaningful‹ - they ›point beyond themselves‹. And this, if we think about it, is the perfect translation in aesthetic terms of the possible world evoked by the classical *Bildungsroman*: a closely woven totality of ›connections‹ that allows individuality to preserve itself *as such* while acquiring *a wider significance.*«[41] Which of course implies a contradiction, since these novels present a single and constant, as well as a changing personality that unfolds over time. The Bildungsroman seeks to resolve this paradox through the idea of personal development resulting in a closed unity. The genre thus ultimately confronts this concept of manageable change with the radical changes of »the age of revolutions«; it considers things as imaginable only in their historicity, but it presents this history as a transparent and controllable process.[42] This is perhaps the most important structural similarity between the genre and time-series graphs, since the latter also present changes over time in a way that aims to manage them. All kinds of ›revolutions‹, such as ›technological‹ or ›industrial‹, have also been planned and controlled by graphs during modernity.

This common development, however, soon diverges: the later instances of the Bildungsroman point out the contradictions between such planning and grand processes on the one hand, and individual lives on the other. The first step (Stendhal) is the incompatibility of possibilities and desires, the second step (Balzac) is the way in which the idea of continuous development and

[40] It is an interesting and open question whether Goethe, the state official, knew Playfair's work. In his political-geographical book on America, written in 1812, his friend and correspondent Alexander von Humboldt cites Playfair as an example to follow, and he made his diagrams a model for his own research, see Funkhouser 1937.
[41] Moretti 1987, p. 62. Emphasis in the original.
[42] Moretti 1987, p. 63.

acceleration is only functioning in terms of larger systems, in which the individual finds less and less of a place for themselves.[43] Nowadays, even these large systems do not always seem predictable and manageable, making it even more difficult to adapt personal perspectives. Graphs are often not tools for a predictable future and transparent processes anymore; they are increasingly informing us of dangers and disasters. Often, the aim by collective action is to make a graph show as little change as possible, and to reduce the slope of curves. This attitude is most clearly expressed in a slogan of the COVID-19 pandemic, which aimed at ›flattening the curve‹: people would rather do nothing than contribute to a further rise in the trendlines.

At the same time, in the field of the humanities, other concepts of time have appeared since the second half of the 20th century in the analysis of historical processes, highlighting the constructed nature of concepts of linearity and progression. Several works have drawn attention to the temporality of individual events, which cannot be resolved into a single homogeneous structure[44], and to what Koselleck calls the »simultaneity of non-simultaneous«[45] or more generally, »multitemporality«. This is particularly interesting for our subject because multitemporality is exemplified by the emergence of data science and data visualisation in literary studies since the 2000s: the new knowledge made possible by the new methodology, and the use of computer capacity in general, represent »the future already begun«, while the graphical representation of historical processes can be interpreted as »the past still present«, in so far as it reasserts an earlier concept of historicity.

What Moretti calls distant reading, and the way digital literary studies works can be easily understood by the increased role of diagrams. Graphs, Maps, Trees, published 18 years after the book on Bildungsroman, even includes in its title the plots discussed so far – but since then there also have been countless examples of time series graphs in the Digital Humanities (while tree- and map-like representations have proved less productive). Even the detection of the *narrative arc* is vibrant area of the discipline.[46] The historical approaches, however, lack the element of prognosis, and differ in this respect from the aforementioned disciplines that relate time series graphs to the cultural technique of prediction: the humanities are concerned with description, but not with future processes. Rather, they are aimed at exploring the past; in which, probably again due to the shortage of data, they are more concerned with identifying unidirectional trends rather than cyclical changes.

Thus we see that not only the structure of narratives, but also the discourse about them, is increasingly shaped by time-series diagrams. At the same time, and in the same way as these representations in relation to development and predictability has been called into question, the faith of (computational) literary historians in them also has been shaken. Moretti too, in their reflection on the use of regression and trend lines with Oleg Sobchuk another 14 years later, notes that they obscure the very elements under study by their homogenising, uniform appearance. »Don't they [scholars] see their own data? Of course they do; but trend lines have changed how we see: they have transformed statistical abstractions into physical presences as real as the data themselves – and in fact, usually, *far more visible than* the data themselves. Visualization appeals to our intuition; if it shows a cloud of dots with a line in the middle, we only look at the line. It's inevitable. And so, instead of helping us analyse the evidence, averages have often allowed us to forget it. We turned to quantification because we wanted to see all those documents that the predominance of the canon had made invisible—and now that they are in front of our eyes, we have found a way not to see them!«[47]

6. Conclusion

And this brings us to the end of our wide-ranging overview; which is also the starting point for this essay. By asking how data visualisation techniques work and what is their cognitive role, (digital) humanities make it possible to gain relevant insights into the structure of knowledge in our culture and to develop a reflective, even critical, relationship with our diagrammatic operations. This includes the evaluation of the data and mathematical methods used to create the graphs; the analysis of the rhetoric manifested in the layouts; suggestions for new ways of representing them;[48] and, more generally, an exploration of the impact of graphs on the way the world can be stored, processed and communicated. Meanwhile, we must not forget the historical study of diagrams, which allows us to situate our contemporary practices and the images they produce within the cultural history of

[43] Moretti 1987, p. 130.
[44] See e. g. Kracauer 1966.
[45] Koselleck 1979, pp. 320–330.
[46] The researches on the narrative arc can be grouped into the following categories: 1. dictionary-based text analysis – subcategories include 1.1 sentiment analysis (see Fudolig et al. 2022; Reagan et al. 2016). and 1.2. frequency analysis of function words and cognitive verbs (see Boyd et al. 2020); 2. the detection of thematic (see Toubia et al. 2021); or 3. grammatical-stylistic changes in texts (like sentence length, word richness) – although »the discussion on how to model plot has reached a point in recent years where that, which is described as plot in CLS [Computational Literary Studies], has only a very vague resemblance with what people in literary studies and beyond mean, when they use the term.« (Konle / Jannidis 2022, p. 319).
[47] Moretti / Sobchuk 2019, pp. 94–95.
[48] Like the rehabilitation of the tree-form by Moretti / Sobchuk 2019; see also Sobchuk 2019.

knowledge production. Since cultural phenomena are not timeless, but are the results *and* drivers of historical change; as are the categories of *time* and *historicity* themselves. This paper intended to take the first, tentative steps towards such investigations. The question now is from what concept of historicity to write the history of time series graphs.

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