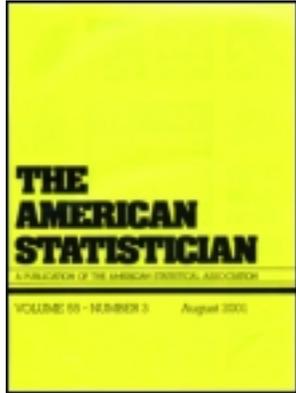


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André-Michel Guerry's Ordonnateur Statistique: The First Statistical Calculator?

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History Corner

André-Michel Guerry's *Ordonnateur Statistique*: The First Statistical Calculator?

Michael FRIENDLY and Nicolas de SAINTE AGATHE

A document retrieved from the archives of the Conservatoire National des Arts et Métiers (CNAM) in Paris sheds new light on the invention by André-Michel Guerry of a mechanical device for obtaining statistical summaries and for examining the relationship between different variables, well before general purpose statistical calculators and the idea of correlation had even been conceived. Guerry's *ordonnateur statistique* may arguably be considered as the first example of a mechanical device devoted to statistical calculations. This article describes what is now known about this machine and illustrates how Guerry probably used it in his program of *statistique analytique* to reason about the relationship of types of crimes to various potential causes or associations. Supplementary materials for this article are available online.

KEY WORDS: A.-M. Guerry; Crime mapping; History of criminology; History of statistics; Moral statistics; Statistical calculators.

1. INTRODUCTION

André-Michel Guerry (1802–1866) was one of the inventors of modern social science and a founder of the empirical study of criminology. He established the idea of using statistical summaries of “moral statistics”—rates of crimes, suicides, out-of-wedlock births, and so forth—to show that these rates could be used to argue for the existence of laws governing human action in the social world, just as inanimate objects were governed by laws of the physical world.

In a few major works (Balbi and Guerry 1829; Guerry 1832, 1864), he also broke new ground in using thematic cartography and data visualization to examine questions concerning the relationship between such moral variables—for example, is increased education or literacy associated with a diminution

of crime? How do out-of-wedlock births relate to education or numbers of priests? These questions were the subject of intense debates in France and elsewhere in Europe at this time over what we would now call “social policy”—how to decrease crime, suicide, and other social ills. This was also at a time well before even the idea of correlation had been conceived by Galton (1886), yet Guerry pursued the goal of studying constancies, variation, and relationships in data on moral variables.¹

A previous article by the first author recounted in detail Guerry's work on these questions, together with the challenges this poses for modern multivariate statistical analysis in a spatial context (Friendly 2007). Another article provides, as complete an account as could be determined, of his personal and family history (Friendly 2008). In these articles, and long afterward, with much assistance from colleagues, there were two main historical topics that remained unresolved. In my files, I classified these as the “Guerry Mysteries.” This article reports a solution to one of these, Guerry's *ordonnateur statistique*, which may now arguably be considered the first example of a mechanical device devoted to statistical calculations.²

1.1 The Guerry Mysteries

Guerry worked his entire professional career on the problem of making sense of the vast quantities of data on social and moral statistics that had just begun to be systematically collected by government agencies in France around 1820 (and then elsewhere in Europe). His initial treatment, in *Essai sur la Statistique Morale de la France* (Guerry 1832), contained numerous tables detailing rates of crime by type of crime, age and sex of the

¹ This does not imply that Guerry was either alone or first in this line of inquiry. Quetelet (1831) and others carried out some related analyses of the national data on crimes in France collected by the ministry of justice starting in 1825. See Perrot (1976) for details of this early history.

² The best one-word English translation of the French *ordonnateur* is “organizer,” with the initial sense of putting in order (sorting), and later, tabulation and classification. Truly general mechanical devices for this purpose begin somewhat later with Herman Hollerith and his punched card sorter/tabulators around 1880. As late as the 1950s, *ordonnateur* continued to be used in France for electromechanical tabulators and sorters. Around 1955, IBM France introduced the modern neologism *ordinateur* for programmable machines, a renaming to also avoid the Franglais words *computeur* and *calculeteur* (see <http://www.les-infostrategies.com/article/0505148/l-ordinateur-50-ans-deja>.). As we describe in what follows, it is therefore fair to regard the *ordonnateur statistique* as a device for statistical calculations.

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accused, department of France, and even season of the year. These were accompanied by semigraphic tables that overlaid trend lines on the numbers (e.g., to visualize the prevalence of different crimes according to age) and choropleth maps of France showing the geographical distributions of these variables.

His final work, *Statistique Morale de l'Angleterre Comparée avec la Statistique Morale de la France* (Guerry 1864), comprises data on over 226,000 cases of personal crime from over a 25-year period in England and France classified in various ways and over 85,000 suicide records, classified by motive and other factors. Guerry (1864) estimated that if all his numbers were written down in a line, they would stretch over 1170 meters.

The first mystery concerns the fate of Guerry's unpublished notes and work-in-progress after his death on April 9, 1866. In the introduction to Guerry (1864), he makes clear that this was just an initial presentation and that detailed analyses and conclusions based on this data would be the subject of yet another book. In Friendly (2008), I recount my search for these articles, which I have traced to his long-time friend, Hippolyte Diard, and a proposed project in 1867–1868 to publish these in the annals of the *Société d'Agriculture, Sciences, Arts et Belles Lettres* . . . in Tours. Alas, this project was not completed, and his articles may have vanished in the large-scale destruction that accompanied the Franco-Prussian war (July 1870–May 1871).

The second and really nagging question was how he did this work. A partial answer was provided by the opening line of the biographical blurb in the Larousse (1876) *Grande dictionnaire universel du XIX siècle*:

Il inventa l'ordonnateur statistique afin de simplifier les opérations mathématiques. Guerry a introduit l'usage des statistiques dans l'étude des phénomènes humains et en particulier de la criminalité. . . .³

However, this turned out to tease more than satisfy. From the necrology notices published (Diard 1867) after Guerry died, I learned that Guerry's *ordonnateur statistique* had been donated by his heirs, André and Charles Poisson, to the Conservatoire des Arts et Métier (CNAM) in Paris. However, all efforts over several years to locate the device or even a description at CNAM failed entirely.

Part of this mystery is that (apart from brief biographical entries) we were also unable to locate any mention of the *ordonnateur* in *any* subsequent writings about early French calculating machines, for example, d'Ocagne (1893) and Bolle (1929). So, how did Larousse know to feature it in the dictionary entry for Guerry? Our guess has been that the writer took this as a significant fact from the necrology notice by Maury, published in Diard (1867, p. 5).

2. THE ORDONNATEUR STATISTIQUE

It turned out that I was not the only one interested in uncovering information about this device. In 1984, the second

³ He invented the statistical organizer to simplify mathematical operations. Guerry introduced the use of statistics in the study of human phenomena and in particular crime.

author was working on his thesis on the topic of a history of the use of numbers in health for the *Faculté de Médecine et de Pharmacie de Besançon (de Sainte Agathe 1988)* and visited the CNAM to inquire about Guerry's *ordonnateur statistique*.

A search by an archivist led to the reply that (a) the *ordonnateur statistique* could not be found, and had been removed from the inventory, but (b) a two-page typewritten description was discovered. This description is unsigned and undated; it was written on a manual typewriter with proper French accented characters and a shift key, so this would place it roughly between 1900 and 1960. This document provides the first concrete information about the goal, design, and operation of Guerry's device, and serves as the basis for this note.

In the course of this work, we have also located an entry for this invention in the official CNAM catalog for 1906, Conservatoire National Des Arts Et Métiers (1906, p. 206), which simply reads

— Ordonnateur statistique pour le calcul des rapports de coïncidences.⁴ Statistique analytique, par M. A. Geurry (sic) (1854).

We note that the title given here is not identical to that in the typewritten description (“rapports de coïncidences” rather than “rapports de concordance”) and the catalog entry lists no accession number (—), so the exact reference to this in the CNAM collection is unclear.⁵

2.1 Description

The original document provided by the CNAM and a parallel French–English typeset version are available in the online supplement and at <http://datavis.ca/papers/ordonnateur/>. We provide a summary of the description below, and an illustration of the use of this device in Section 2.2. Lacking the actual device, or even a photograph or Guerry's own account, the following represents our interpretation as best as we understand it.

The purpose of the device is given in the opening paragraph as providing a means to assess the concordance between different moral and social variables:

This machine has the aim of classifying in a given order the records which list numbers to be added by groups. In the work of statistical analysis, one compares values ordered according to a certain character/trait in order to understand the influence of this character on the studied values. For example we may have similar comparisons when analyzing the relations which may exist between criminality in a country, density of the population and the level of education.

The machine was designed to work from a table listing the 52 English counties in rows, with the various social, moral, and crime variables in columns and then converted to ranks within

⁴ Statistical organizer for the calculation of reports of coincidences.

⁵ A recent inquiry to the museum staff at the CNAM led to the conclusion that the *ordonnateur statistique* was registered in the collection as late as 1941. It could not be found in 1984, and in 1991, the museum underwent a large renovation causing many items in the vast collection to be relocated. An effort to complete the verification and cataloging of the collection is still underway, so there is a (faint) hope that something new will be uncovered in the next 3–4 years.

each column. It consisted of a cylinder on whose circumference there were 52 rotatable bands, each containing 58 holes into which one could push a peg. The table was then cut into strips for each variable and these were wrapped around the cylinder.

Let us suppose that the classification of the English counties, initially according to the number of fires, then according to the number of murders, is in conformity with the following indications:

Counties	Rank according to number	
	Fires	Murders
Derby	1	42
Stafford	2	27
Brecon	3	25
Norfolk	4	6
...

The operation of the device is described as follows:

We will turn the cylinder so that the lines of holes show up successively. In the first line one will push the peg at the 42nd hole, another with the 27th hole of the second line, then at the 25th hole of the third line; at the 6th hole of the 4th line, and so on.

In a special frame put in front of the machine the rows are arranged separately according to the old order (fires). If then we turn the cylinder using a crank, the pegs which show up successively on the same line in turn come to take down the levers that drive out the rows to be classified in the new order, i.e. the rows numbered 42, 27, 25, 6 — in the order of classification following the order of the murders.

The penultimate paragraph points to the use of this device to calculate summaries of the relationship between the two variables so aligned.

A dial meter with ringer makes it possible to stop after each series of ten rows. The rows thus are laid out on a tablet, which conveniently allows adding the numbers in the column. Using the totals formed one then calculates the averages and the coefficients useful for the analysis of the results.

From this account, it thus appears that the primary function of the machine was for sorting one target variable in relationship to another, focal variable, as one might do today in a spreadsheet. Having done that, one could then manually calculate summaries (averages) for the ranks of the target variable or others carried along by sorting.

The author of this document concludes:

The organizer of Mr. Guerry probably constitutes the first application of mechanics to statistical evaluations.

2.2 Use

From the description above, we can now be reasonably sure that the ordonnateur was designed as a special-purpose device to summarize the relationship between a given moral variable or rate of crime and other factors that might provide some explanation or description.

With the emphasis on ranking by one attribute, and turning the crank so that the rows for another variable are arranged

in correspondence, it is clear that the goal was to assess the correspondence between the two rank-ordered series.

One might think that this goal was easier to achieve with a smoothed curve on a scatterplot, except that Guerry was unaware of the invention of the scatterplot by Herschel (1833), which was rarely used until the time of Galton (Friendly and Denis 2005). In any case, even the idea of correlation was unknown in Guerry's time, and the ordonnateur at least provided some means for examining the possibly nonlinear relationship between two variables.

This principle of use is best illustrated by Plate 17 in Guerry (1864), shown here slightly enhanced in Figure 1.⁶ This semi-graphic table, titled *Causes Générales des Crimes* is Guerry's most ambitious and impressive graphical invention, and designed to illustrate his program to replace simple descriptive statistics, typically in simple tables, with "analytical statistics," whereby numerical data can be made to yield general abstract results by calculation and summarization.

This chart is headed "Comparative Libration⁷ of the Crimes of Each Type and the statistical elements with which they are linked in their geographical distribution." The rows of the upper panel show 23 types of crime ordered by frequency and seriousness from the top (debauchery, bigamy, domestic theft) to the bottom (fraud, rape, murder). The columns pertain to the rank order of the 52 counties of England on each crime separately, as prepared for the ordonnateur. For example, row 1, for debauchery has its maximum in Middlesex (7400) and minimum in Cardiff (0), while row 23, for murder is maximal in Derby (1986) and minimal in Cardiff (0), the numbers being rates per 10,000 persons.

The body of the table shows a wide variety of symbols for moral and social characteristics found with varying degrees of prevalence entered in the cells for the counties ordered within each row. The legend at the bottom lists the following kinds of symbols: (a) aspects of population (density, percentage of Iris, agricultural, domestics, etc.); (b) aspects of criminality (prevalence of male, female, young, old, relative to average); (c) degree of instruction (of males, criminals, prisoners); and (d) religion (Anglicans, Catholic, etc.).

Overlaid on the chart are several sets of lines and curves tracing the "center of libration" (think of a geographic "average") of these social indicators. The red lines for the symbol (a), for population density, trace the correspondence of this factor over the various crimes, so that one can see directly to which crimes it was related positively (bigamy and domestic violence) and which were negatively related (arson and cattle theft). The middle panel, which provides summaries for crimes against persons and crimes against property, shows that both of these are high in regions of high population density. Two other smoothed curves,

⁶ In order to allow detailed study, this figure is also provided in high-resolution formats in the supplementary materials and at <http://datavis.ca/papers/ordonnateur/>.

⁷ "Libration," from the Latin for "balancing," is an astronomical term referring to points of gravitational equilibrium in the oscillating motion of two orbiting bodies relative to one another.

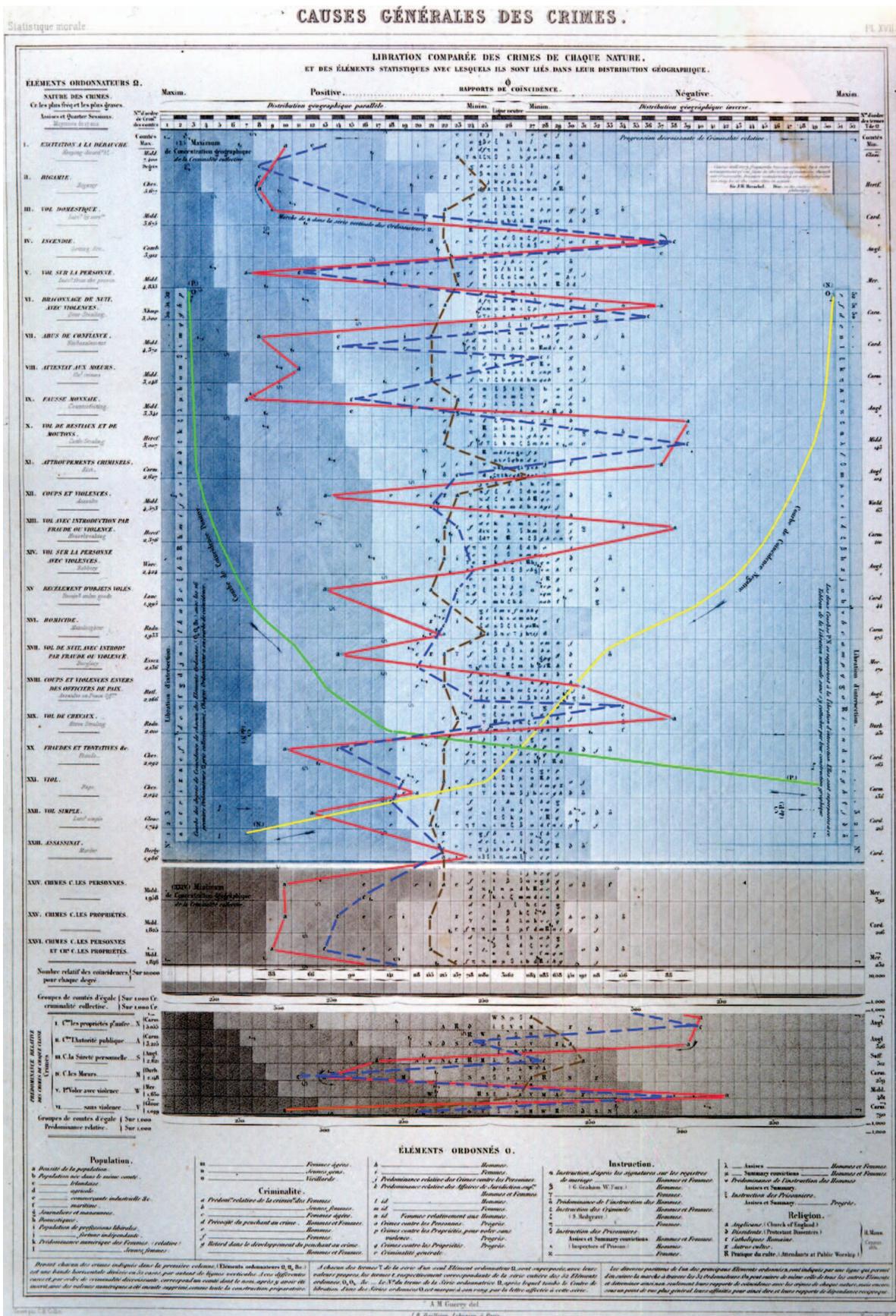


Figure 1. Guerry's 1864 Plate 17: General causes of crimes. Several colored lines tracing the "center of libration" of factors associated with crimes of various types have been emphasized in the figure. The line in red, for example, traces population density. Source: Courtesy of Staatsbibliothek zu Berlin.

starting at the left (right) are labeled “curve of positive (negative) coincidence.”⁸

Thus, with the organization and summaries of these data provided by the *ordonnateur*, one could ask questions such as “Which social factors are positively and negatively associated with crimes of each type?” For example, in Figure 1, we have added two more lines of libration to Guerry’s original, showing the relative numbers of Catholics (dashed, blue) and Anglicans (dashed, brown). The pattern for Catholics is similar to that of population density, and thus largely associated with the same crimes, while the curve for Anglicans does not vary much across type of crime.

The inset quotation from J. W. Herschel (1831) in the box at the upper right sums up Guerry’s anticipation of the utility of this method: “Causes will very frequently become obvious by a mere arrangement of our facts in the order of intensity . . .” His *ordonnateur* was the mechanical means to make these relations more apparent.

2.3 Date

There remains the question of ascribing a date to Guerry’s invention. A handwritten note by the second author lists 1854 as the date, and this corresponds with the CNAM Catalog entry (Conservatoire National Des Arts Et Métiers 1906, p. 206). However, there is now suggestive evidence that the actual date was somewhat before 1851, when Guerry presented two exhibitions of his work in England, an honored public exhibition in the Crystal Palace at the London Great Exhibition, and a second one at the meetings of the British Association for the Advancement of Science (BAAS) in Ipswich.

In the report of the transactions of the Statistics section (Fletcher 1851, p. 101), it is noted,

M. Guerry exhibited eighteen coloured Maps illustrating some important conclusions respecting *the Criminal Statistics of England for 16 years, ending 1850*. . . .

The leading point which he had established for France was, that the common opinion respecting the intimate connection between mere instruction and the absence of crime in particular districts, when compared, was mistaken. . . . Each Map was constructed to show the prevalence in each county of England of a particular crime or class of crime, such as murder, manslaughter, arson, larceny by servants, offenses against the game laws, bigamy, etc. . . .

Besides the maps, he showed a series of tables, exhibiting by curved lines for each county, the degrees of positive and negative criminality corresponding with the coloured maps.

Thus, it is clear that Guerry produced a set of charts similar to Figure 1 (but separately for different crimes) by 1851, very likely with the aid of his *ordonnateur statistique*. In this context, his Plate 17 from Guerry (1864) can be seen as an attempt to compress these into a single comprehensive figure.

⁸ Note that if the symbols for the various social indicators were all connected by lines, the result would be something like a modern parallel coordinate plot, but where the parallel axes are defined by the ranks of counties on the various crimes, rather than by variables.

3. DISCUSSION

The aim of this discussion is to frame the *ordonnateur statistique* in a wider historical context. Guerry’s work (1829–1864) occurred at a time when developments in three main areas coalesced: data, visualization, and technology. For the first time, this allowed the application of scientific methods to informed discussion of significant social, medical, and legal issues, as opposed to the previous arm-chair philosophical debate.⁹

The first ingredient was *data*—the explosive growth of systematic, centralized records kept by state agencies in France, England, and, later, elsewhere in Europe on these topics. Hacking (1990, pp. 73–77) refers to this development as an *avalanche of numbers*, this phrase prompted by his assessment of Guerry’s work.

Second was the idea that suitable *visualization* of these numbers, often preceded by calculation of some simple summary statistics (means, medians, ranks), could shed some light on these issues. Guerry seized on the idea of the shaded (choropleth) maps just invented by Dupin (1826) as a method to show the geographic distributions of these variables. More importantly, such maps for different variables, when viewed side-by-side, provided an initial method to reason about the relationship between moral variables, for example, crimes against persons, crimes against property, and education, as in Balbi and Guerry (1829).

The final component was the emergence of some *technology*, particularly machines for mechanical calculation, that could be used to aid in the process of transforming voluminous raw data into understandable summaries and visualizations from which one could attempt to draw reasoned conclusions. This area also witnessed a pronounced acceleration of growth in Guerry’s time.

Among the earliest such mechanisms were the “Pascaline” by Blaise Pascal (1642), consisting of geared dials for successive digits to perform addition and subtraction and the “Stepped Reckoner” invented by Gottfried von Leibniz (1672), which used a stepped cylindrical drum and gears. By rotating the cylinder with a crank, one could also perform multiplication and division by a mechanical version of successive addition and subtraction. Pascal’s and Leibniz’s designs provided the basic mechanical ideas for most of the arithmetic calculators built during the eighteenth century.

However, it was not until the time of Guerry that even such simple, four-function mechanical calculators became popular, beginning with the “Arithmometer,” patented in France by Charles Xavier Thomas de Colmar (1785–1870) on November 18, 1820. By around 1834, Charles Babbage had developed the initial prototype of the “difference engine,” with the novel idea that such a machine could be mechanically programmed to calculate polynomial approximations to a wide variety of functions (logarithmic, trigonometric, etc.), using a mechanical analog of the method of divided differences. In 1853, George Scheutz

⁹ Among these issues, the public and official perception of a dramatic increase in crime loomed large in the period of the Bourbon Restoration from 1815 (Napoleon’s defeat) through 1830. Then, as now, ideas about criminal justice policy ranged from a liberal position, advocating increased education, religious instruction, etc., to a conservative view, advocating building more prisons, harsher treatment of convicts, etc. See Friendly (2007, p. 369) and references cited therein for further details.

(1785–1873) and his son Edvard, of Sweden, constructed the first working difference engine. The Babbage and Sheutz devices together with the Jacquard loom (invented 1801) are considered as the precursors to the modern computing machines.

It is thus fair to say that Guerry's invention of the *ordonnateur statistique* took place in a period when the necessary components for an empirical social science were all first available. He combined them to advantage to create a mechanical device that could serve his program of *statistique analytique*, going beyond simple description to reason about potential causes in what would be his final work (Guerry 1864).

In the larger history of ideas in statistics, data visualization, statistical computation, and modern social science, Guerry's legacy is underappreciated, for reasons I describe elsewhere (Friendly 2008). Yet, his *ordonnateur statistique*, although a special-purpose device, deserves recognition as an early, if not *the* earliest, mechanical device designed as an aid to statistical calculation and assessment of the relationship between variables. We cannot find an earlier exemplar in this category. This must be considered all the more remarkable because even the idea of correlation would not be conceived for another 30 years.

SUPPLEMENTARY MATERIALS

CNAM document Original document (*ordonnateur-statistique.pdf*) and parallel French–English translation (*ordonnateur-translation.pdf*).

Figure 1, high-resolution 300 dpi version with annotations (*guerry1864-17s-lines4.jpg*); original 1200 dpi version (*guerry1864-17.jpg*).

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