

# Paper Knowledge and Statistical Precision

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**Abstract:** This essay explores the material imperatives of nineteenth-century statistical ambition, at a time when the nature of paper itself underwent rapid change. It expands the concept of paper technologies to include knowledge about the materials themselves, as well as the infrastructures, techniques, and agreements that made it possible for the right kind of paper to be made available for particular purposes. Taking the production of the forms for the Prussian census as a case in point, it argues that the enumeration effort of Prussian census statisticians went far beyond designing a form, collecting information, noting and compiling figures, or creating tables. Paper knowledge to define and control the material substance of the forms mattered as much as political impetus and statistical methods in getting the census right.

The flourishing of statistical reasoning in the nineteenth century is closely linked to the collection and analysis of census data. This essay takes the 1871 Prussian census card—called the *Zählkarte* (counting card)—as a starting point to explore the material imperatives of nineteenth-century statistical ambition at a time when the nature of paper itself was undergoing rapid change. The card depicted here—a sturdy, slightly rough, and now somewhat yellowed form the size of a paperback novel—is held today in the files of the Royal Prussian Statistical Bureau housed at the Prussian Secret State Archive in Berlin, together with extensive official correspondence that not only offers detailed information about the methodological and logistical preparations that were made for the census but also documents the material process that created this new paper form (see Figure 1). The evidence includes internal cost calculations and public solicitations for bids, as well as precise accounts of which printing shop was ultimately commissioned to produce the new individual census cards, the criteria that were applied in making the choice, and the particulars of the contract awarded for their production.

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**A. Volkszählung am 1. December 1871.** 202 ..

**Herzogthum Lauenburg.**

Ort, Gemeinde .....

Straße oder Platz ..... Haus Nr. ....

Zählbezirk Nr. .... Zählbrief Nr. .... Zählkarte Nr. ....

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Man wolle vor Beantwortung der gestellten Fragen die Anleitung D. vergleichen.

1. Vor- und Familiennamen: .....
2. Geschlecht: .....
3. Geburtsort: .....

Kreis: ..... Staat: .....

4. Geburtstag und Geburtsjahr: .....
5. Familienstand: .....
6. Religionsbekenntniß: .....
7. Stand, Rang, Beruf, Erwerbszweig; Arbeits- oder Dienstverhältniß.  
 Hauptbeschäftigung: .....

Etwasige, mit Erwerb verbundene Nebenbeschäftigung: .....

8. Staatsangehörigkeit (Name des Staats): .....
9. Wohnort (der Personen, die für gewöhnlich nicht an der Haushaltung theilnehmen): .....

Kreis: ..... Staat: .....

10. Schulbildung, d. h. kann lesen und schreiben? .....
11. Besondere, die Bildungs- oder Erwerbsfähigkeit beeinträchtigende Mängel:  
 blind?      taubstumm?      blödsinnig?      irrsinnig?

**Figure 1.** Individual counting card for the Prussian census of 1871. Geheimes Staatsarchiv Preußischer Kulturbesitz (GStA PK), I. HA Rep. 77 Ministerium des Innern, Tit. 94, no. 132, Vol. 1, p. 202.

These official paper trails accounting for the cards’ material genesis have so far been of little interest to historians of statistics and quantification. To date, the carefully crafted paper form has come into view as a finished product, as part of a growing body of work invested in paper technologies, a concept that has been employed primarily to examine processes of scientific, bureaucratic, artistic, or craft work that take place *on* or *with* paper.<sup>1</sup> Consequently, such investigations

<sup>1</sup> For a discussion of the term “paper technologies” see Anke te Heesen, “The Notebook: A Paper-Technology,” in *Making Things Public: Atmospheres of Democracy*, ed. Bruno Latour and Peter Weibel (Cambridge, Mass.: MIT Press, 2005), pp. 582–589; Latour and Weibel, *Der Zeitungsausschnitt: Ein Papierobjekt der Moderne* (Frankfurt am Main: Fischer Taschenbuch, 2006); and Carla Bittel, Elaine Leong, and Christine von Oertzen, eds., *Working with Paper: Gendered Practices in the History of Knowledge* (Pittsburgh: Univ. Pittsburgh Press, 2019).

of knowledge practices, cultural techniques, and the materiality of writing systems have rarely focused on the material substances of the paper stuff in use.<sup>2</sup> Taking the production of the Prussian counting cards as a case in point, this essay aims to expand the concept of paper technologies to include knowledge about the materials themselves, as well as the infrastructures, techniques, and agreements that made it possible for paper of a particular quality and in the required quantities, thicknesses, and grades to be made available for particular purposes.<sup>3</sup>

The counting card, introduced in 1871 as a cutting-edge enumeration tool, was bound up with ambitions both statistical and governmental in nature. Central to a complete overhaul of procedures to establish scientific standards in census taking, which aimed to enable more complex forms of statistical aggregation, the counting card was designed as a mobile data carrier that integrated the population directly into the generation of data. Heads of households were expected to fill out one card for each household member in their own hand, as a way of vouching for the accuracy of their statements. The very layout of the card reflects this aim: the main section contained eleven questions followed by dotted lines that left room for answers in complete words. Once filled in, the inscriptions on each card formed an irreplaceable data set on one individual; taken together, the cards represented mobile “data doubles” of every one of the twenty-five million persons living in Prussia.<sup>4</sup> The success of the census largely depended on the accuracy and completeness of the information inscribed on each card. This goal was to be achieved by carefully choreographing the local implementation of the census and by embedding these efforts within an extensive state campaign to promote it as a patriotic action voluntarily undertaken for the benefit of all.<sup>5</sup>

As the primary tool of the Prussian state’s ambitious census reform, the card combined two features that differed from commonly used enumeration forms of the time: it served both as a survey instrument and as a device that facilitated compiling the data gathered throughout the entire process, with the aim of making the census as free as possible from disruptions or errors. During the census, which was an extensive and logistically complex undertaking that took months to complete, the cards passed through a number of stations and many hands as they were distributed, filled out in homes, checked by local authorities, and circulated across Berlin to generate complex analyses.

Acquiring and compiling data placed significant demands on each card, and—this is what I will go on to discuss—called for a material with just the right qualities. The paper needed to be stable enough for the cards to be handled and passed around many times, handed out, written on in homes, collected, checked several times, and then sorted and counted manually, all without tearing or falling to pieces. It was also important that the card not be too smooth, preventing it from slipping out of place amid all the material that was gathered and allowing it to be stacked

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<sup>2</sup> Bruno Latour, “Drawing Things Together,” in *Representation in Scientific Practice*, ed. Michael Lynch and Steve Woolgar (Cambridge, Mass.: MIT Press, 1990), pp. 19–68; Ursula Klein, *Experiments, Models, Paper Tools: Cultures of Organic Chemistry in the Nineteenth Century* (Stanford, Calif.: Stanford Univ. Press, 2003); Markus Krajewski, *Paper Machines: About Cards and Catalogs* (Cambridge, Mass.: MIT Press, 2011); Lisa Gitelman, *Paper Knowledge: Toward a Media History of Documents* (Durham, N.C.: Duke Univ. Press, 2014); Ann Blair, *Too Much to Know: Managing Scholarly Information before the Modern Age* (New Haven, Conn.: Yale Univ. Press, 2011); and Boris Jardine, “State of the Field: Paper Tools,” *Studies in History and Philosophy of Science*, 2017, 64:53–63.

<sup>3</sup> See Christine von Oertzen and Lotte Schüssler, “Für, mit und auf Papier: Papiertechnologien und ihre Versorgungsketten,” *Zeitschrift für Medienwissenschaft*, 2022, 14(2):119–132.

<sup>4</sup> The term “data double” stems from the sociologists Kevin D. Haggerty and Richard V. Ericson and refers to personal data that stand in for actual persons within bureaucracies and take on a life of their own as their “doubles”; see Kevin D. Haggerty and Richard V. Ericson, “The Surveillant Assemblage,” *British Journal of Sociology*, 2000, 51:605–622.

<sup>5</sup> See Christine von Oertzen, “True to Form: Media and Data Technologies of Self Inscription,” *Science in Context*, 2021, 34(4), forthcoming.

in piles. And yet it needed to be no thicker or heavier than absolutely necessary in order to minimize the weight and volume of the cards throughout the entire operation.

Unlike official documents such as cadastral books or birth and death registers, individual counting cards were designed as official working tools with a limited lifetime. In the long run, it was only the statistical aggregates generated from the individual data that counted.<sup>6</sup> Most of the cards themselves were sold, in accordance with the principle of Prussian thriftiness, to the paper industry as wastepaper after the count was completed. There was thus no need for the paper to be especially durable.<sup>7</sup> However, all cards had to be made of exactly the same material, because differences in thickness, smoothness, or weight would have severely disrupted efforts to standardize and control the counting process as thoroughly as possible.

For the 1871 counting card, a print run of thirty million copies was needed, in a single delivery at a precisely specified time—and this was not even the only form used in the census. The total weight of all the paper used in these cards, the additional forms meant to accompany them, control lists, and envelopes for the 1871 census amounted to 375 tons. The design, procurement, production, and circulation of counting forms of the right size, thickness, quality, and color were inherent components of the paper technologies used for Prussia's manual data processing. The sheer number of these counting cards makes it clear that their material was the essence of a far-reaching counting system that the Prussian state employed to generate quantitative knowledge about itself, based on direct, handwritten statements by all heads of household.

Prussian statisticians, in the largest state of the unified German Empire, also hoped that the 1871 census would offer a demonstration of their scientific prowess. Ernst Engel, the director of the Prussian Statistical Bureau and a key initiator of the census reform, described the new procedure of gathering and compiling census data in analogies based on scientific methods and instruments. Like the Belgian astronomer and statistician Alphonse Quetelet, he defined state statistics as the “physics of society,” whose task it was “to observe the physical, mental, political, and social life of peoples in the states they inhabit in their phenomena, to capture them arithmetically, and to demonstrate analytically, as it were, the causal connection between cause and effect of these phenomena.” He thus saw statistics as akin to a “physical apparatus,” “laboratory,” or “terrestrial observatory” that must be as powerful and well constructed as possible in order to observe and record objectively social and economic phenomena and interrelated effects that remain hidden to the naked eye.<sup>8</sup> The counting card used to collect data for the census was considered a precision instrument in this sense, and the officials of the Statistical Bureau paid a great deal of attention to its material condition.

The introduction of the counting card coincided with radical changes in paper production, which demanded a special level of material knowledge from the officials of the Prussian Statistical Bureau. In the last third of the nineteenth century mechanical wood and straw pulp—and later chemical pulp—became widely used in paper production, changing it fundamentally. Linen and cotton fiber fabrics were hardly ever used in the traditional pure form. The new mechanically or chemically obtained wood or straw fibers, together with an increase in mineral fillers, enabled an unprecedented expansion of the supply of paper. Yet most of the new product was wood and straw

<sup>6</sup> On this point see Dan Bouk, “The History and Political Economy of Personal Data over the Last Two Centuries in Three Acts,” *Osiris*, 2017, N.S., 32:85–106.

<sup>7</sup> The ash residue of a burned sample sheet was not allowed to exceed 20 percent; see the contract concluded between the Prussian Statistical Bureau and Dr. August Brass, owner of the *Norddeutsche Allgemeine Zeitung* and the Wilhelm Köbke printing works operating on its behalf, 16 Aug. 1871, Geheimes Staatsarchiv Preußischer Kulturbesitz (GStA PK), I. HA Rep. 77, Tit. 94, no. 132, Vol. 1, pp. 87–91, esp. p. 88. The best linen papers leave a residue of less than 3 percent when burned.

<sup>8</sup> Ernst Engel, “Über die Organisation der amtlichen Statistik mit besonderer Beziehung auf Preußen,” *Zeitschrift des Königlich-Preussischen Statistischen Bureaus*, 1861, 1:53–56, on p. 53.

paper that was brittle and yellowed rapidly. The addition of chlorine bleach and other tricks managed to give the new paper—at least at first—a smooth white shine, concealing—at least for some time—the true nature of its brittle inner texture.<sup>9</sup>

The use of the counting card, together with its accompanying forms, multiplied the total amount of paper required for the census. From the point of view of the Statistical Bureau, the imperative that all census forms have a consistent quality required that they be sourced from a single producer.<sup>10</sup> And since reliable quality standards did not exist, the office developed its own guidelines for all the materials it needed. It specified the maximum quantities of low-grade fibers as well as the chemical and mineral admixtures permitted in each case. As part of a rigorous bidding process, it then also scrupulously checked compliance with the specifications. In 1871, thirty-nine companies submitted paper samples, together with their bids to produce the robust counting cards and their accompanying documents, lists, and envelopes; all samples were tested on site for strength, smoothness, and heaviness and then sent for chemical laboratory testing, where the ash residue was also determined.<sup>11</sup> Several samples failed the test; overly expensive suppliers were eliminated; and ultimately the list shrank to the few printers who could promise to deliver all thirty million counting cards on time from the same material while also providing space for storage.

The decision was finally made to choose the producer and publisher of the government-affiliated Berlin daily newspaper *Norddeutsche Allgemeine Zeitung*. Once the contract was awarded, the printing of cards and lists took more than four months. The publisher was obligated to allow bureau officials access to the factory and printing plant at all times during this period to ensure that everything met the promised quality.<sup>12</sup> And whereas this first order in 1871 certainly bore traces of improvisation, the bureau subsequently refined its paper purchasing into a standard process. Later censuses required paper samples to be delivered in sealed packages. On a specified date, they were then opened, examined, and subjected to initial tests in the presence of all companies bidding on the contract. Winning a contract one year was no guarantee of future orders; the sample paper submitted always dictated the outcome.<sup>13</sup>

Beginning in 1884, the Prussian statisticians also received scientific support from the Paper Testing Department of the Mechanical and Technical Testing Institute at the Royal Technical University of Berlin. Founded in 1880 as a forerunner of today's German Federal Institute for Materials Research and Testing, the institute's mandate was to test the durability of a range of materials key to the industrial age, from iron and other metals to building materials and machine oils. Chemical and mechanical methods such as stress tests were applied to identify the components and purity of substances or to determine the breaking point of hard matter (*feste Stoffe*).<sup>14</sup> The Paper Testing Department had been added primarily in response to complaints from the authorities about the declining stability and durability of the official or "civil servant

<sup>9</sup> Regarding the defects of the new wood and straw paper see Heinz Schmidt-Bachem, *Aus Papier: Eine Kultur- und Wirtschaftsgeschichte der Papier verarbeitenden Industrie in Deutschland* (Berlin: De Gruyter, 2011), pp. 27–40; and Alexander Friebe, "Ohne Papier keine Zeitung: Die Erfindung des Holzschliffpapiers als Meilenstein in der Entwicklung des deutschen Pressewesens," *Jahrbuch für Kommunikationsgeschichte*, 2001, 3:132–156. On the apparent improvement achieved by adding chlorine see Egbert Hoyer, *Das Papier: Seine Beschaffenheit und deren Prüfung* (Munich: Ackermann, 1882), p. iv.

<sup>10</sup> Director of the Prussian Statistical Bureau Ernst Engel to Minister of the Interior Friedrich zu Eulenburg, report on the contracting of paper supplies for the census, 20 July 1871, GStA PK, I. HA Rep. 77, Tit. 94, no. 132, Vol. 1, pp. 65–69, esp. p. 65v.

<sup>11</sup> *Ibid.* On paper testing in the early modern period see Gabriella Szalay, "Paper Trials, Multiple Masculinities, and the Economy of Honor," in *Working with Paper*, ed. Bittel et al. (cit. n. 1), pp. 60–74.

<sup>12</sup> See the contract concluded between Prussian Statistical Bureau and Brass (cit. n. 7), Vol. 1, p. 90.

<sup>13</sup> See Prussian Statistical Bureau to Ministry of the Interior, concerning the submission of the counting papers required for occupational statistics in Prussia, 11 Mar. 1882, GStA PK, I. HA Rep. 77, Tit. 94, no. 151, Vol. 1, pp. 193–199, esp. p. 196.

<sup>14</sup> "Materialprüfung," in *Meyers Konversationslexikon* (Leipzig: Biographisches Institut, 1885–1892), Vol. 11, p. 335.



paper” needed for long-term archiving.<sup>15</sup> The botanist and chemist Wilhelm Herzberg served as this department’s first director. It was at this research institute that Herzberg created the first set of binding standards for various kinds of paper (and ink) used by the authorities, depending on the requirements the paper had to meet and how long documents had to be preserved.

In a treatise titled *Papier-Prüfung*, or “Paper Testing,” Herzberg provided a glimpse into the work of his laboratory.<sup>16</sup> The volume, which was reprinted many times and grew in size with each new edition, provided information on the latest instruments and techniques, such as tearing, crumpling, folding, bending, moistening, and burning, that could be employed to compel various types of paper to reveal the linen, wood and straw pulp, mineral fillers, and other chemicals that had been used in their production. Herzberg’s book set quality standards for the paper industry primarily because it provided practical guidance for on-site paper testing. The accompanying illustrations, such as microscopic views of the structure of various paper fibers and their color reactions to tinctures of chlorine, zinc, or iodine, provided visual aids for evaluating chemical tests (see Figure 2). Such chemical mixtures were easy to produce without any specialized assistance, and they could be carried around in small quantities, making them ideal for *ad hoc* use during official paper tests.



**Figure 2.** Microscopic representation of the dyeing of linen and cotton, wood and straw pulp, and wood pulp fibers in chlor-zinc-iodine solution. From Wilhelm Herzberg, *Papier-Prüfung* (Berlin: Springer, 1894), Plate 14.

<sup>15</sup> Wilhelm Herzberg, *Papier-Prüfung: Ein Leitfaden bei der Untersuchung von Papier* (Berlin: Springer, 1888), p. iv.

<sup>16</sup> *Ibid.*

The paper technologies of the Prussian Statistical Bureau thus went far beyond designing a form, collecting information, noting and compiling figures, or creating tables. They included activities that took place *for*, *on*, and *with* counting cards and created the conditions for a new form of state knowledge and governmentality based on the census. For the Statistical Bureau, the reliability of statistical surveys was thus tied, in a very specific way, to the paper itself and to material knowledge about it. As a material, a tool, and ultimately a difficult-to-handle mass of physical objects, paper required specific technical and political handling and monitoring to anchor the census as a government practice in the culture of objectivity and precision prevalent in the exact sciences of the time. It was the totality of these knowledge practices that constituted the paper technologies of Prussian statistics and underpinned the validity of the figures they produced. Quality, standardization, and control of the material mattered as much as political impetus and statistical methods in getting the census right.

Translated by Michael Thomas Taylor