The Shape of History: Reimagining Nineteenth-Century Data Visualization

Caroline Foster

Georgia Institute of Technology United States of America cfoster2@gatech.edu

Adam Hayward

adam.hayward@gatech.edu Georgia Institute of Technology United States of America

Svyatoslav Kucheryavykh

Georgia Institute of Technology United States of America

Angela Vujic

Georgia Institute of Technology United States of America

Maninder Japra

Georgia Institute of Technology United States of America

Shivani Negi

shivani.negi@gatech.edu Georgia Institute of Technology United States of America

Lauren Klein

lauren.klein@lmc.gatech.edu Georgia Institute of Technology United States of America

Introduction

In the mid-1850s, American educator and editor Elizabeth Peabody (1804-1894) set off from Boston to ride the rails. She traveled as far north as Rochester, NY; as far west as Louisville, KY; and as far south as Richmond, VA, in order to promote the textbook she had recently published, *A Chronological History of the United States* (1856). Along with her suitcase, Peabody traveled with a large fabric roll, which, when unrolled, displayed a grid-like array of colored squares that represented the major events in U.S. history. In the nineteenth-century version of a product demo, Peabody would arrange the "painted centuries," as she called them, on the floor, and invite potential textbook adopters to sit around the charts and contemplate the colors and patterns that they perceived (9).

Although not described in terms of visualization-the term did not enter common parlance until the early twentieth century--Peabody's ideas about the uses of her charts anticipate many of the benefits associated with visualization today: the ability to "offload" mental processing "from cognitive to perceptual systems," to "enhance" pattern recognition through "abstraction and aggregation," and, crucially, to interact with and potentially "manipulate" the visualization itself (Card et al. 1999, 16). For Peabody did not only imagine that her readers would interpret the "data" presented on her charts; she also intended for them to create charts of their own. To this end, Peabody also sold workbooks of blank charts, so that students could read each chapter of her textbook, and then convert the list of events that followed into color and position, according to her visual scheme.



Figure 1: Peabody's visualization of the significant events of the seventeenth century. In *A Chronological History of the United States, arranged with plates on Bem's principle* (New York: Sheldon, Blakeman, 1856).

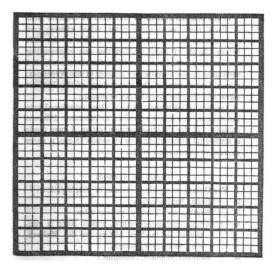


Figure 2: A blank chart included in *The Polish-American* System of Chronology: Reproduced, with some modifications, from General Bem's Franco-Polish method (New York: G.P. Putnam, 1850).

Project Overview

Drawing from recent digital humanities work relating to historical fabrication (e.g. Elliott et al. 2012, Sayers 2015), as well as from our own previous explorations of historical visualization techniques (e.g. Foster et al. 2016), we set out to recreate and enhance Peabody's pioneering visual design. In particular, we focused on Peabody's ideas about interaction and interpretation, since her ideas about the tripartite relation between data, text, and image-- and the role of the reader in translating between each-- speak directly to current debates in the digital humanities about the importance of acknowledging data as "capta" (Drucker 2011), and of recognizing the role of individual interpretation in both the design and reception of visualizations (Posner 2016). In our project, we focused first on reimagining Peabody's original interaction for the web, employing current information visualization research to suggest techniques for emphasizing the interrelation between the data and their visual display. We then began a project to recreate the floor-sized version of Peabody's chart using physical computing materials, so as to further explore the embodied aspects of Peabody's visualization scheme. In the following sections, we describe the design choices involved in each recreation-- the digital and the physical-- with particular attention to how we sought to amplify Peabody's ideas about interaction, interpretation, and embodiment through our reimagined interfaces.

The Shape of History: Reimagining Interaction and Interpretation for the Web

The website located at shapeofhistory.net represents the culmination of a year-long iterative design process. From Peabody's original textbook, we distilled four conceptual modes of interaction: an "explore" mode, designed to explain to novice users how to interpret her charts, and how to translate between text and image; a "lesson" mode, designed to allow users to create their own charts, drawing upon Peabody's original data; a "compare" mode, designed to call attention to how choices in visual display affect the charts' ultimate interpretation; and a "play" mode, intended to facilitate the most open-ended form of interaction and expression. To implement the site, we employed a combination of HTML5, CSS, and JavaScript, including Bootstrap.js for site structure, jQuery for navigation and site-level interaction, and D3.js and two.js (along with custom JavaScript) for the visualization components.

At each juncture, we considered how to enhance Peabody's original designs and interactions. For instance, when recreating the grid that would serve as the primary typographical form, we remained faithful to the original design and color palette, while adding additional minor grid lines (in light gray) so that users would know where to click (White 2011). In order to emphasize the relation between text and image, an important feature of both the "explore" and "compare" modes, we added a simple interaction, known as "brushing," so that hovering over a single event in either the text or the image would simultaneously highlight both elements, as well as the corresponding location on the chart's key (Stasko 2007). For the "lesson" mode, we augmented the features developed for the other two modes with a more guided experience, akin to the lesson that Peabody described in her textbook, through proceduralized interaction (Bogost 2007). In the lesson, users must read each event, one at a time, translate it into color, and then place the colored square in the appropriate location on the grid. Through enhanced user cues, such as converting the cursor to a pointer as it hovers over the grid, and highlighting empty squares as the user hovers over them, users are guided through a digital version of the interactive lesson that Peabody envisioned in print.

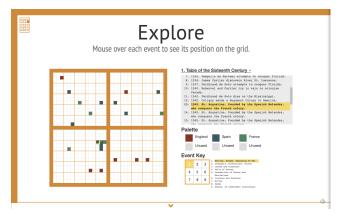


Figure 3: A screenshot of the "Explore" mode, with an event from 1565 highlighted. Viewable at <u>http://www.shapeofhistory.net/</u>.

Reimagining Peabody's historical visualization scheme for the web helps to underscore how she understood interpretation as a fundamental part of the process of perceiving visualizations. Her visual design bears very little relation to the immediately intuitive images that we associate with visualization today. And yet, for Peabody, the abstraction of the chart was part of its purpose; she intended her charts to be individually interpreted by each person who encountered them. More than that, she envisioned her charts as lessons in themselves--lessons that often took time and effort in order to complete. In this way, the interactions she envisioned, while made quicker and more intuitive through their digital recreation, lose some of their original intent, in that Peabody did not identify efficiency as a feature of her designs. Instead, she viewed the interpretive process--sometimes difficult and often slow-- as the best source of historical knowledge. The "lesson" of The Shape of History, as distinct from Peabody's original scheme, is a reminder of how little interpretation is intended-- even if it is still required--when encountering visualizations of data today.

The Floor Chart: Reimagining Embodiment through Physical Computing

While the digital version of the project emphasizes Peabody's interest in facilitating interaction and interpretation, it does not convey the embodied aspects of the original interaction; looking at a screen is a far different experience than walking around a rug-sized chart on the floor. To reimagine this embodied mode of interaction, we designed a one-meter by one-meter floor chart, consisting of a matrix of thirty by thirty individually addressable light-emitting diodes (LEDs). Each LED corresponds to one subsection of Peabody's original chart, so that the 900 possible events can be represented. (We cannot account for multiple simultaneous events, however). The LEDs can be pre-programmed via custom software, which makes use of Adafruit's NeoPixel library. We are also in the process of developing a flexible touch interface, using conductive copper tape and neoprene, so that the LEDs can be controlled through a soft button-like interaction. Both the LEDs and the touch interface are controlled by an Arduino Mega 2560 microcontroller.



Figure 4. The LED matrix.

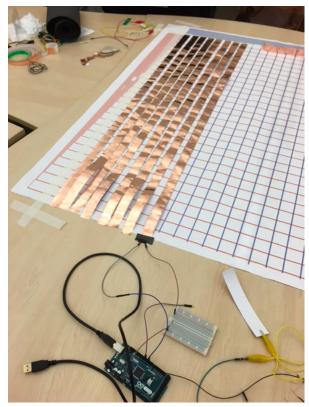


Figure 5: The touch interface in progress.

We view this project as one of speculative design (Dunne and Raby 2013). Since Peabody's original floor charts were not preserved, we must speculate about everything from the size of the chart, to the colors employed, to the events depicted. While we have textual accounts, in Peabody's correspondence, of how nineteenth-century viewers would interact with the floor charts, the original charts were obviously not programmable. What the reimagined floor chart teach us, then, is about how we might incorporate embodied elements into current visualization design practices, as much as about how viewers interacted with large-scale visualizations in the past. It also reminds us about the labor involved in fabricating the original charts. (Peabody complained about the magnitude of the task in her correspondence). The work of data visualization, while not always expressed in physical form, is always the work of many hands.

Conclusions and Next Steps

In their foundational essay on historical fabrication, Devon Elliott et al. observe that "working with actual, physical stuff offers the historian new opportunities to explore the interactions of people and things" (2012). In this project, we have sought to extend these opportunities for exploration to include the interactions of people with data, as well as with their visual display. Our project underscores the foundational role of interpretation in designing and perceiving visualizations; and shows how interaction is crucial to the interpretive process. It also points to future modes of visualization, not yet imagined, that might better emphasize embodied ways of knowing. In terms of next steps, for the website, we plan to think through what a more scholarly version of the site, with room for more explanatory text, might look like. For the physicalization, we are continuing to implement the touch interface. From there, we will focus on the aesthetic aspects of the rug, exploring options for light-diffusing fabrics to frame the LEDs, and light-blocking materials to create the grid-lines.

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