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# INFORMATION VISUALIZATION

Hsuanwei Michelle Chen

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# Information Visualization

*Hsuanwei Michelle Chen*

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## About the Author

**Dr. Hsuanwei Michelle Chen** is an Assistant Professor in the School of Information at San José State University. Her primary areas of research and teaching interests include data mining, information visualization, social network analysis, and online user behavior. In particular, she is interested in studying the value of virtual platforms, social media, and networked environments, and the role they play in shaping online user behavior. She has published on the topics of information visualization, social media, and online user behavior in journals such as *Journal of Information Technology Management*, *Library Management*, *Information Systems Research*, and *Decision Support Systems*. She holds a BS and MS in computer science and information engineering from National Taiwan University and a PhD in information systems from the University of Texas at Austin, McCombs School of Business.

## Abstract

Information visualization has been widely adopted as both an analytical tool and an aid to enhance and shape data interpretation and knowledge discovery in disciplines ranging from computer science to humanities. On the other hand, relatively less has been discussed, applied, or even understood in terms of its role in a library setting. This issue of *Library Technology Reports* (vol. 53, no. 3), "Information Visualization," will share a comprehensive introductory piece focused on presenting a wide range of aspects of information visualization, including its definitions, major principles, and common techniques. Author Hsuanwei Michelle Chen will also provide an in-depth discussion and demonstration of how information visualization can be applied to a library setting. The objective of this issue of *Library Technology Reports* is to provide librarians and library staff with a better grasp of what information visualization can do for their institution. This includes pertinent information on how data analytics, communication, service quality, and work effectiveness can potentially be enhanced by using information visualization. The report also appeals to readers who are new to the field and would like to learn a new method of data analytics, as well as to the individual who is experienced in information visualization and is seeking further opportunities in the library field.

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# Contents

# An Overview of Information Visualization

In this chapter, readers will be provided with an overview that covers the history, evolution, and definition of information visualization. Chapter 2 will introduce and address the fundamental concepts and knowledge in information visualization, including major visualization principles, types, and techniques. A special focus will be placed on the introduction of emerging software tools, such as Tableau and Google Charts.

In chapters 3 and 4, insight into the applications and practices of information visualization in libraries will be covered, with chapter 3 specifically describing the driving forces that necessitate information visualization in libraries and current trends and directions. Chapter 4 presents real-world cases in which information visualization is used to improve library activities, services, and programs. It also addresses user experience enhancements via better data interpretation, discovery, and understanding.

Chapter 5 describes an overview of challenges and opportunities derived from the interplay of information visualization and the library. Then, chapter 6 will list pertinent instructional resources and learning opportunities for librarians and library professionals who are interested in diving deeper into this field.

Finally, a brief overview of the contents covered will recap the flow of the information provided, offering insight into the transitions of the technology discussed.

## History and Evolution of Information Visualization

The history of information visualization dates back to the sixteenth century, when geometric diagrams and maps were used to aid navigation and exploration. From that point on, information visualization has evolved considerably, with each century bringing new methodologies into the equation. The seventeenth century saw the rise of analytic geometry, as well as the birth of measurements and theories that were used to estimate time, distance, and space. It was also during this period that significant fields of study and information processing were founded, including estimation, probability, demography, and the entire field of statistics. All of these things significantly advanced the way solutions were made, thereby paving the way for *visual thinking*.

The birth of visual thinking was followed by expansion in the use of economic statistics that involved the use of numbers pertaining to social, moral, medical, and other statistics. These figures were used for governmental response, such as policy making and activity planning, in the eighteenth and nineteenth centuries. During the same period, information visualization shifted, and the use of diagrams to illustrate mathematical proofs and functions became commonplace.[1] These centuries also saw an evolution in information visualizations as nomograms that aided in calculations were developed. Apart from nomograms, other impactful inventions were created, including modern graphic forms such as line graphs, histograms, scatter plots, and others.

Yet it was just in the twentieth century that information visualization began to become even more prominent. This was in part due to significant developments in information visualization, especially in the late twentieth century. For example, it was in the 1970s that the power of information visualization was introduced as a means of exploring and making sense of data.[2] In 1977, Princeton statistics professor John

Tukey introduced exploratory data analysis, known as EDA. EDA was and remains a predominant visual approach to exploring and analyzing data. With the emergence of computers, an exciting path was paved to help cultivate the use of information visualizations that people could actually view and interact with using a computer. Since then, according to American psychologist and professor Michael Friendly, information visualization and its techniques have expanded and evolved yet again, now displaying large networks, databases, and text, especially in organizations where there are persistent problems of large-scale data presentation that continue to emerge. Big corporations and libraries are two such organizations.[3]

## Information Visualization Definitions and Basics

Humans perceive things in a variety of ways, such as through smell, taste, hearing, and vision. Among all the senses, vision is considered very dominant, as it has a wide "bandwidth" (the bit-rate of consumed information capacity) for sensing.[4] In addition, human vision is *pre-attentive*.[5] Pre-attentive vision is broadly defined as the visual processes that operate before humans attend to an object. During this stage of visual search, early visual processes operate in parallel over a large portion of the visual field, extracting information from each item's basic visual features. For example, human vision is highly selective when it comes to different sizes, shapes, colors, spatial positions, and so on, and that is what makes human vision a powerful tool for data analysis and interpretation. By organizing and presenting data in a carefully designed, selective way, one can exploit human vision to gain different interpretations and understandings from the data. Additionally, vision helps extend memory and cognitive capacity, both of which play a significant role in how people process information. By considering all these facts and findings, an exciting portrait reveals itself, one that has led to the emergence of the study of information visualization. Since a picture is worth a thousand words, it becomes a significant and noble pursuit to study the issues involving how one can translate plain data into a graphical display that speaks to the audience in a more intuitive, powerful way.

To help understand information visualization, let's break down both words and evaluate them individually. What is information? According to Stephen Few, an educator and innovator in the field of information visualization, information comes from items, entities, and things that cannot and do not have a direct correspondence to physical structures or objects.[6] Some good examples include football statistics, stock market prices, connections between socioeconomic status and criminal rates, and relationships between car attributes and mileage per gallon. On the other hand, examples for an entity that has a correspondence to physical structures or objects include human anatomy and three-dimensional cell structure. The "information" in this context is abstract, as it comes from an analysis of some type of data. The second part of information visualization is visualization. *Visualization* refers to the creation of two-dimensional or three-dimensional representations of data that enable new discoveries of both insights and knowledge.[7] With the close connection between human vision and cognitive capacity, visualization can also be seen as the use of computer-supported, interactive visual representations of data to enhance cognition.[8] Together, these two words describe a new meaning that has changed the way we perceive information and understand data in a highly impactful, more memorable manner.

The views of information and visualization bring up two important aspects to consider: (1) information visualization is used to discover new insights and knowledge from abstract data through graphical means; and (2) information visualization can be considered a representation of data that amplifies cognition. Card, Mackinlay, and Shneiderman explained the overall information visualization process using a "reference model," in which three subprocesses are included.[9] First, there is the data transformation subprocess, which transforms raw data into data tables that offer structure and ease of manipulation. Second, data tables are mapped onto visual structures that include the application of spatial substrates, marks, and graphical properties. With the third subprocess, view transformations, visual structures are transformed into human views, which involves graphic parameters, such as position, scaling, and clipping.

Based on the discussions above, there is no singular definition or concept of information visualization. Through evaluating Few's work, it is noted that he explains his thoughts and research on information visualization by sharing this: "The use of images to represent information . . . is only now becoming properly appreciated for the benefits it can bring to business. It provides a powerful means both to make sense of data and to then communicate what we've discovered to others."[10] In another work, Friendly defines information visualization as "the science of visual representation of 'data,' defined as information which has been abstracted in some schematic form, including attributes or variables for the units of information."[11] Friendly's definition offers valuable insight, which resonates with the most comprehensive definition of visual information proposed by Hal Varian, Chief Economist at Google and emeritus professor at the University of California, Berkeley. Varian defines information visualization as "the ability to take data—to be able to understand it, to process it, to extract value from it, to visualize it, and to communicate it."[12] In an article by Jayanta Kr. Nayek and Dibakar Sen, information visualization is defined as "a method for representing data accurately on the web and elsewhere. It gives a unique perspective on the data set. It is a representation of data in a visual context, which helps to understand the significance of data. There are different types of data, which require different representation to fulfill different purposes, like musical data, geographical data, scientific data, etc."[13]

Just like the definition of information visualization, the purpose or the use of information visualization has also evolved over the years. For example, in *Smashing Magazine* cofounder Vitaly Friedman's article, he defines the purpose of information visualization as the "ability to visualize data, communicating information clearly and effectively" but also "in a more intuitive way."[14] The Institute of Development Studies explains the purpose of data visualization as a way "to explain and to explore data" to "be used as a tool for analysis, finding patterns as well as discovering questions amongst other things."[15] Today, the way we define information visualization is grounded in the visual elements, and in particular pictorial or graphical formats. Its key use has been identified as its ability to help decision makers see analytics, further helping them to comprehend difficult concepts and even identify new patterns. The evolution of digital technologies has only broadened the use of information visualization as it is now being used to extract information from data for more detail. Current trends and demands show us that information visualization is now interactively changing the way the human brain visualizes and processes complex data. Information visualization is easier for the brain to process than other forms of data, such as reports or spreadsheets.

## Conclusion

The term *information visualization* is easily associated with thoughts of making graphics and images. However, it truly offers more insights than that alone. Information visualization is a cognitive process that is used for analysis and presentation, allowing us to better understand data and offering the opportunity to act upon the understanding it offers. It also enables effective communications and presentations, further solidifying the fact that the purpose of visualization is to gain insights, not simply to view pictures.

## Notes


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# Information Visualization Principles, Techniques, and Software

## Perceptual Properties

Of all the human senses, vision is considered a primary and powerful channel of input. It takes in everything from the world around us and transmits this information to the brain for an instant analysis of what it means. With this intimate connection that vision has with cognition comes the first step toward learning and creating visual designs, which is through understanding how human visual perception works. Visual perception is relative, constantly scanning, constantly adjusting focus, and constantly adapting. A well-known example, which is presented in figure 2.1, demonstrates how written words are perceived in a way that is different from what most people may initially think. According to research in word recognition and how the human brain reads letters, the order of letters in a word does not matter; the only important thing is that the first letter and last letter are in the right place.[1] Our vision relays the information to our brain, which takes care of processing what has been seen. Even when an entire paragraph contains numerous spelling errors, people can still comprehend it without any problems and often without even realizing that there are any errors in the text. Figure 2.1 serves as a nice demonstration of how human vision and cognition interact: the human mind does not read every letter by itself; instead, it processes the word as a whole. This example also illustrates the complex and mysterious nature of human vision. Even more, it creates extensive opportunities for visual designers to take advantage of human visual perception as it pertains to information visualization. Among all the unique characteristics of vision, two perceptual properties are commonly applied in information visualization: pre-attentive processing and the Gestalt Laws.

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It deosn't mttaer in what oredr the ltteers in a wrod are,
The olny iprmoatnt thing is
That the first and last ltteer be in the rghit pclae.
The rset can be a taotl mses and you can still raed it wouthit a porbelm.
This is bcuseae the huamn mnid deos not raed ervey lteter by
istlef, but the wrod as a wlohe.
Amzanig huh?

*What the above text says:*
I couldn't believe
That I could actually understand what I was reading.
The phenomenal power of the human mind.
According to research at Cambridge University,
It doesn't matter in what order the letters in a word are,
the only important thing is
That the first and last letter be in the right place.
The rest can be a total mess and you can still read it without a problem.
This is because the human mind does not read every letter by
itself, but the word as a whole.
Amazing, huh?

**Figure 2.1**
Word recognition: how our brain reads letters (from Jinxi Caddel, "Word Recognition: How Our Brain Reads Letters," *Learn, Think, Inspire* [blog], February 4, 2010, www.jinxiboo.com/blog/2010/2/4/word-recognition-how-our-brain-reads-letters.html).

### Pre-attentive Processing

Pre-attentive visual processing, which takes place in the sensory memory, is fundamental for creating visual representations. Pre-attentive visual attributes are perceived by viewers almost instantaneously and without the intervention of consciousness. One of the key issues in the study of information visualization is to investigate how the human visual system processes and analyzes an image. An important initial result of this research was that a small number of visual

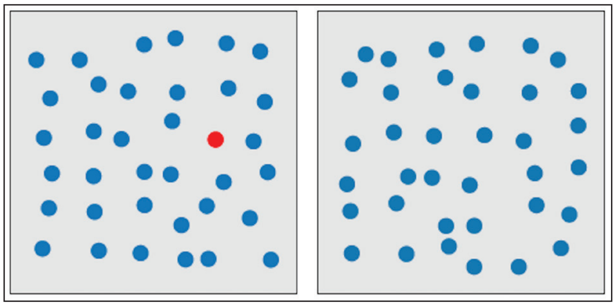

**Figure 2.2**
Search for a target red circle based on a difference in hue (from Christopher G. Healey, "Perception in Visualization," North Carolina State University, Department of Computer Science, last modified September 24, 2016, https://www.csc.ncsu.edu/faculty/healey/PP/index.html).

properties can be detected rapidly and accurately simply by the "low-level" visual system. These properties were termed pre-attentive since their detection appears to precede focused attention.[2] It may be difficult to fully perceive the value of this insight, but understanding pre-attentive processing is important for visualization design. In particular, by exploiting pre-attentive processing capability, several important design questions can be answered, such as, What can be perceived immediately? Which visual properties are good discriminators? What can mislead viewers? How can one design the information so that it pops out?

Christopher G. Healey from North Carolina State University has created a website to demonstrate what pre-attentive processing means in regard to the experience of information visualization.[3] One of his examples is given in figure 2.2. This figure shows how to search for a target circle based on a difference in colors—the darker circle pops out immediately among all the lighter circles. This is a basic, yet common use of pre-attentive processing. Some other basic tools used in pre-attentive design include length, width, and intensity. There are also more advanced symbols, which include lighting and motion direction.

### Gestalt Laws

Gestalt Laws, which are also known as the Law of Simplicity and the Law of Pragnanz (which entails the entire visual), describe how to arrange visual symbols in a graphical display that is optimized to achieve a better, more effective visualization. These laws focus on how people interpret the world, providing relevant principles in relation to perceptual organization. Gestalt Laws were first proposed by German psychologists in the early 1900s.[4] Their primary purpose was to assist in understanding pattern perception, while also providing clear descriptions of many basic perceptual phenomena. While psychologists call them laws, these principles are more like heuristics, which are mental shortcuts for solving problems.[5]

**Figure 2.3**
Gestalt Laws: the faces-vase drawing (from Edgar Rubin, "Figure and Ground," in *Visual Perception: Essential Readings*, ed. Steven Yantis [Philadelphia, PA: Psychology Press, 2000], 225–29).

One of the well-known Gestalt Laws is known as "figure and ground," also called the "faces-vase" drawing, shown in figure 2.3.[6] The foreground of this image is the "figure," while "ground" is what is behind. This drawing exemplifies one of the key aspects of the figure-ground organization and edge assignment, along with its effect on shape perception. One can notice that in the faces-vase drawing, the perceived shape depends critically on the direction in which the border between the black and white regions is assigned. The perception of figure, as opposed to ground, can be thought of as part of the fundamental perceptual act of identifying objects.

It must be acknowledged that Gestalt Laws play a significant role in information visualization. These laws apply in the creation of graphs in which visual elements are designed so as not to interfere with each other. Specifically, according to Gestalt Laws, the design of visualizations should avoid unexpressive marks, use perceptually effective encodings, and not distract the audience. Creating an effective and expressive visual design with a truthful message is a high priority in information visualization.

## Information Visualization and Cognition

In one of the definitions of *information visualization*, it is stated that "the use of computer-supported, interactive visual representations of data to amplify cognition" is necessary.[7] This close connection between information visualization and human cognition is emphasized. One of the noted benefits of graphics is to help simplify the search for information that is needed for task completion through the aid of human vision. In particular, in order to crystalize knowledge, data is needed. When data alone is not able to easily provide information, the use of information visualization can help. Visualization aids cognition due to the ways that it increases memory and the processing of resources available through pre-attentive properties, Gestalt Laws, and many other perceptual properties. By simplifying the search for information and enhancing the recognition of patterns, visualization enables perceptual inference operations.

## Tufte's Principles for Information Visualization

Edward Tufte is the man the *New York Times* called "the da Vinci of data" because of his concisely written and artfully illustrated books on the visual display of data.[8] In addition to being noted for his writings on information design, Tufte is also a pioneer in the field. Through his work, he proposed key principles in designing visualizations, which have offered substantive and important insights into displaying information for maximum effect and ease of comprehension.

One consequence of Tufte's principles is the ability to achieve graphical excellence through information visualization. According to Tufte, graphical excellence is "the well-designed presentation of interesting data—a matter of substance, of statistics, and of design."[9] Knowing that graphical excellence consists of complex ideas communicated with clarity (no ambiguity or confusion in graphs), precision (truthful results and distortion-free presentations), and efficiency (a minimal amount of chart "junk"), this is a critical point of concern. Graphical excellence is what will give the viewer the greatest number of ideas in the shortest amount of time and with the least ink possible in the smallest amount of space. Such graphical excellence can be achieved by accomplishing two goals: (1) telling the truth about the data, which is achieved by graphical integrity principles, and (2) visualizing with clarity and precision, which is achieved by design principles.

Graphical integrity principles are concerned with having clear, detailed, and thorough labeling, which can be used to prevent graphical distortion and ambiguity. Tufte also defined the "lie factor" as "a value to describe the relation between the size of effect shown in a graphic and the size of effect shown in the data."[10] Specifically, the representation of numbers, as physically measured on the surface of the graphic itself, should be directly proportional to the quantities represented. Another design principle that Tufte introduced was the "data-ink ratio."[11] Tufte referred to data-ink as "the non-erasable core of a graphic, the non-redundant ink arranged in response to variation in the numbers represented."[12] By definition, non-data-ink is the ink that does not convey information but is used for scales, labels, and edges. To further expand on this, the data-ink ratio is "the proportion of ink that is used to present actual data compared to the total amount of ink (or pixels) used in the entire display."[13] The lesson in all of these details and objectives is that good graphics should include only data-ink; all non-data-ink should be deleted whenever possible to avoid drawing attention to distracting, irrelevant elements in the presentation. The goal is to design a display with the maximum possible data-ink ratio without eliminating something that is necessary for effective communication.

The non-data-ink concept also leads to the discussions of avoiding "chart junk." Chart junk is all the visual elements in charts and graphs that are not necessary for the viewer to comprehend the information represented on the graph or that distract the viewer from this information.[14] Examples of unnecessary elements that are chart junk include heavy or dark grid lines, unnecessary text, or inappropriately complex font faces. In addition, ornamented chart axes and display frames, pictures or icons within data graphs, and ornamental shading and unnecessary dimensions are in danger of being considered chart junk.

Interestingly, there has been research on people's acceptance of this "minimalist" approach to visualizing information.[15] Research that disagrees with what Tufte has written suggests that there are circumstances in which chart junk is considered useful and effective. These information visualization scholars have argued that elaboration is not all bad and that visual embellishments may have other benefits. In particular, when graphs are used with the purpose of persuasion or presentation, they should be designed with the specific objective of aiding the memorability of the presented data. Through evaluation of existing research, it has been supported that a data graphic must engage the reader's interest, something that can be achieved through the use of graphic imagery.[16]

There is another widely adopted design principle proposed by Tufte that addresses "data density" as being beneficial for a good graphic. Data density is defined as "a ratio of the number of entries in data array to the area of data graphic."[17] Intuitively, there are three ways to increase data density: including small multiples, including sparklines, and simply maximizing the amount of data shown. The approach that is referred to as "small multiple" figures addresses a collection of miniature illustrations arrayed as a single figure, which is designed to be perceived as one.

When talking about the sparklines approach to create a graphic of small multiples, Tufte described them as being “data-intense, design-simple, and word-sized graphics.”[18] The third approach, that of maximizing the amount of data shown, simply refers to showing as much data as possible.

## Information Visualization Techniques

There is a wide range of techniques to be utilized when it comes to information visualization. These techniques range from simple charts, such as bar and line graphs, to more advanced techniques, such as heatmaps and scatter plot matrixes. Some of the techniques are created for a specific purpose, thereby making it hard to categorize them. In this section, the primary focus will be on introducing several commonly used information techniques.

Let’s start by defining *multivariate data*, as it is a common term and concept used in many of these techniques. *Multivariate data* refers to data of more than three dimensions. In other words, there are more than three variables per case in the data set.

The first approach to visualizing multivariate data is through multiple views.[19] With this technique, if one cannot present the dimensional data all in one graph, one can try to display them in multiple graphs, with each of the graphs conveying a certain message. Figure 2.4 provides an example of the multiple views technique.[20] In this example, a matrix of data is presented on the left of figure 2.4, with five variables in each row and five variables in each column. The intersection presents the value corresponding to the specific row and column. This matrix is a good choice for numerical representation, but it is also difficult to retrieve any pattern or relationship of the data from the matrix at first glance. The logical progression of thought would be to determine a more intuitive way to give each variable its own display, as shown on the right of figure 2.4. In this visual display, each variable, 1 to 5, is given a graph, with variables A to E on the x-axis and their corresponding values on the *y*-axis. The visual display demonstrates how a multivariate data representation can be partitioned into five sub-graphs, with each sub-graph mapping the data on a two-dimensional plane. While this visualization technique is easy to implement and intuitive, an immediate drawback exists: as the number of variables increases, the number of sub-graphs needed for each variable also increases. This increase creates a risk of having too many sub-graphs presented at one time, which increases the noise level, making information comprehension and processing challenging.

A more sophisticated approach to visualizing multivariate data is through the use of a scatter plot matrix. The scatter plot matrix is one of the graphical tools beloved by visualization designers. A scatter plot renders a visual display to capture the correlation between a pair of variables. Given a set of *n* variables, there are *n*-choose-2 pairs of variables, and thus the same numbers of scatterplots.[21] These scatter plots can be organized into a matrix, making it easy to represent and observe all pairwise correlations in one place. Figure 2.5 shows an example of a scatter plot matrix visualization based on Nate Silver’s feature article about the most livable neighborhoods in New York.[22] In this article, Silver’s ranking formula considers twelve factors, such as housing affordability, green space, transit, and night life, and calculates an overall score using the individual scores from the factors based on their chosen weights. For example, housing affordability is weighted 25 percent. Scores are then converted to ranks. The intent of this visualization by Kaiser Fung is to look at whether the individual factors are correlated. For example, what is the correlation between housing price and housing quality in a neighborhood? Are more diverse neighborhoods also more creative? What about better schools? Several observations can be easily drawn from this visualization. For example, in the top left corner, the slant shows that the more affordable the houses are, the worse the transit is; the better the shopping is, the better the dining is. An interesting observation, though only a moderate correlation, is that more diversity seems to lead to lower creative capital.

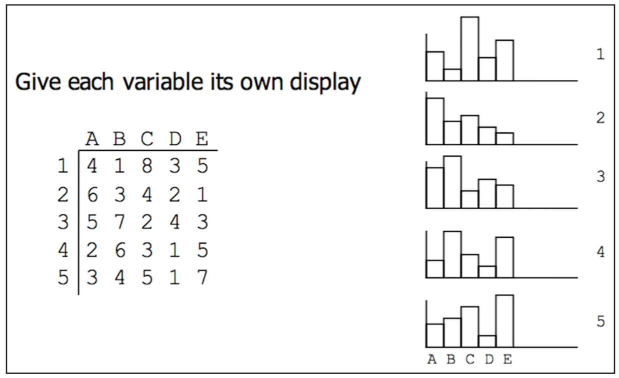


**Figure 2.4**
A multiple-views technique example (from John Stasko, “Multivariate Visual Representations 1” [lecture, Georgia Institute of Technology, Atlanta, GA, September 14, 2016]).

A specific type of visualization that most consider to be highly interesting, perhaps even fascinating, is called Chernoff Faces. Herman Chernoff is an applied mathematician, statistician, physicist, and educator who invented Chernoff Faces to display multivariate data using the shape of a human face. In Chernoff’s paper from the *Journal of the American Statistical Association* in 1973, he proposed that simplified, cartoon-like face shapes were able to represent a number

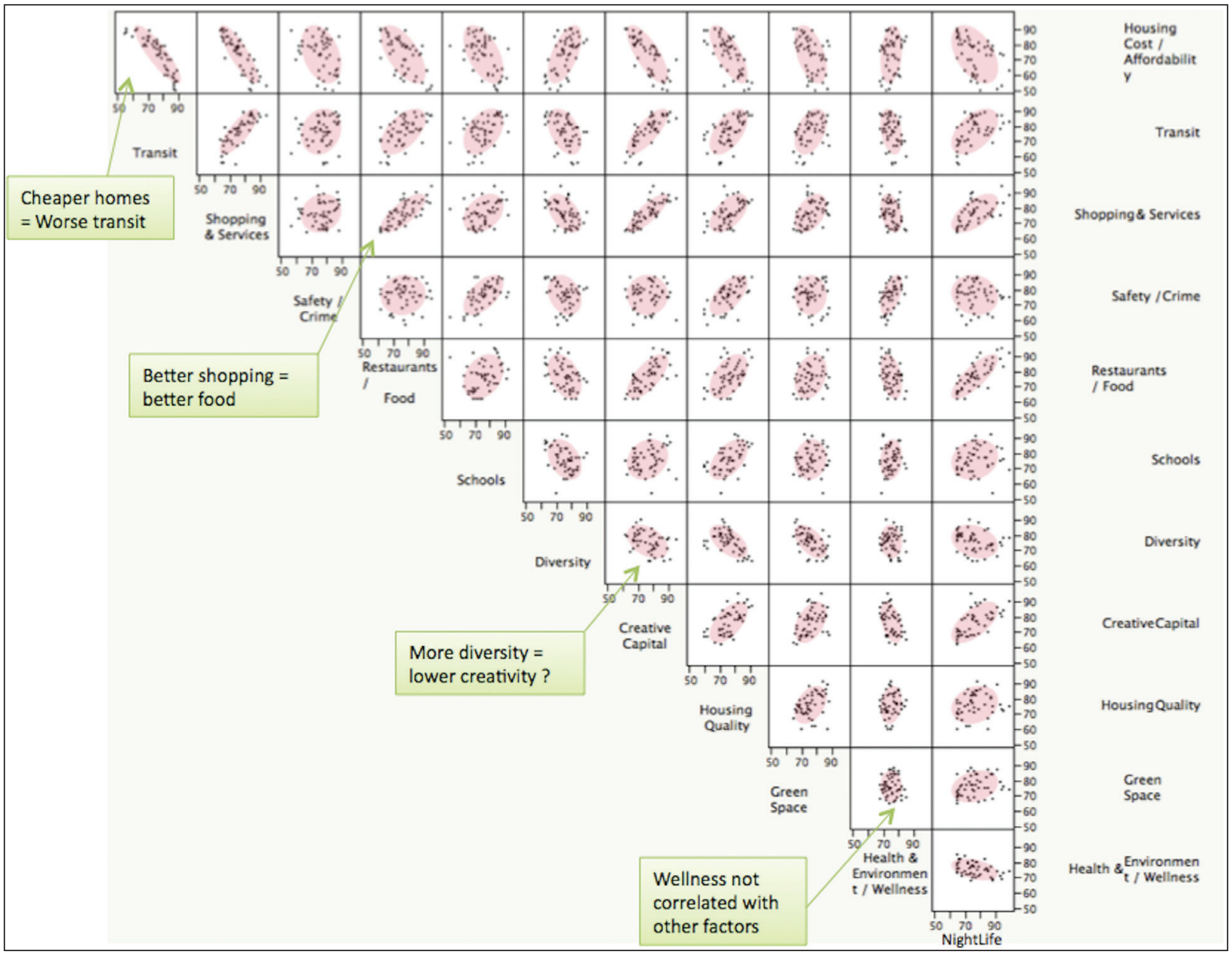


**Figure 2.5**
A scatter plot matrix technique example (from Kaiser Fung, "The Scatter-Plot Matrix: A Great Tool," *Junk Charts* (blog), June 17, 2010, http://junkcharts.typepad.com/junk_charts/2010/06/the-scatterplot-matrix-a-great-tool.html).

of variables in a data set.[23] By mapping numbers to head eccentricity, eyebrow shape, eye size, eye eccentricity, pupil size, nose size, nose width, mouth curvature, mouth width, and mouth openness, a visual understanding could be achieved. The Chernoff Faces help viewers more quickly and precisely detect patterns, groupings, and correlations. The rationale was built upon the fact that the human mind has the innate ability to recognize small differences in facial characteristics and to assimilate many facial characteristics at once. One well-known example of using Chernoff Faces has been used to display life in Los Angeles in 1970, as shown in figure 2.6. This depiction was created by Eugene Turner, a geography professor from California State University.[24] In this map, the four variables to describe life in Los Angeles include affluence, unemployment rate, urban stresses, and the percentage of white population. These variables are presented by facial elements, including face shape, mouth curvature, eyebrow slope, and face color, respectively. The well-known map accurately and aesthetically captured the living conditions in the Los Angeles area. People attribute the success of the award-winning map to the effective, symbolic use of Chernoff Faces. Turner described this map as "probably one of the most interesting maps I've created because the expressions evoke an emotional association with the data."[25]

When a data set is comprised of purely categorical data, a popular visualization tool called a mosaic plot is used. A mosaic plot allows analysts to examine the relationship among two or more categorical variables. The mosaic plot starts as a square with length one, which is then divided horizontally based on the proportions of the probabilities associated with the first categorical variable. Then each horizontal bar is further split vertically based on the proportions of the conditional probabilities of the second categorical variable. Additional splits can be made using a third and fourth variable, and so on.[26] Figure 2.7 shows a simple example of a mosaic plot that shows

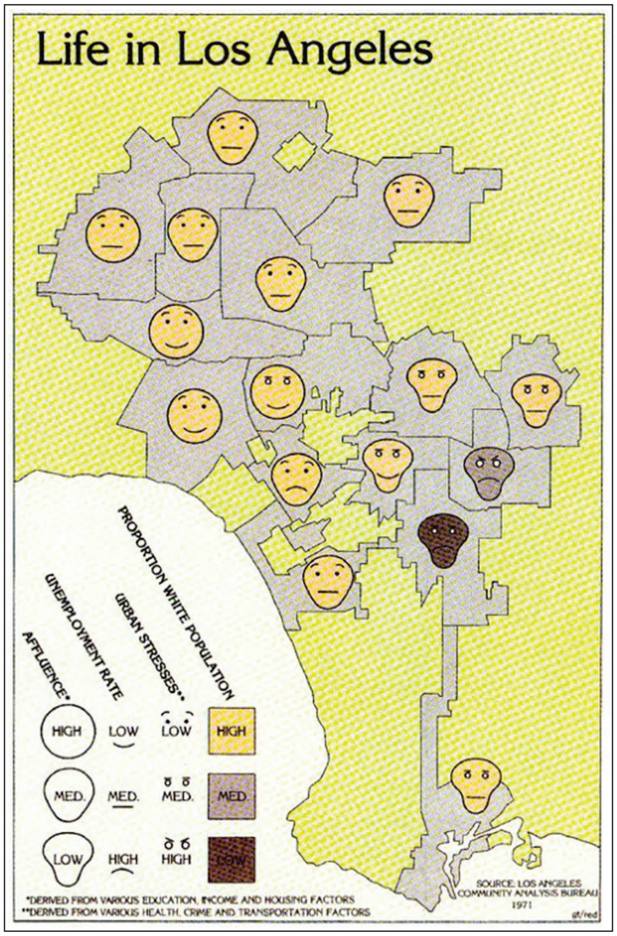


**Figure 2.6**
A Chernoff Faces visualization for life in Los Angeles in 1970 (from Eugene Turner, "Life in Los Angeles 1970," California State University Northridge, accessed October 4, 2016, www .csun.edu/~hfgeg005/eturner/images/Maps/lifeinla.gif).

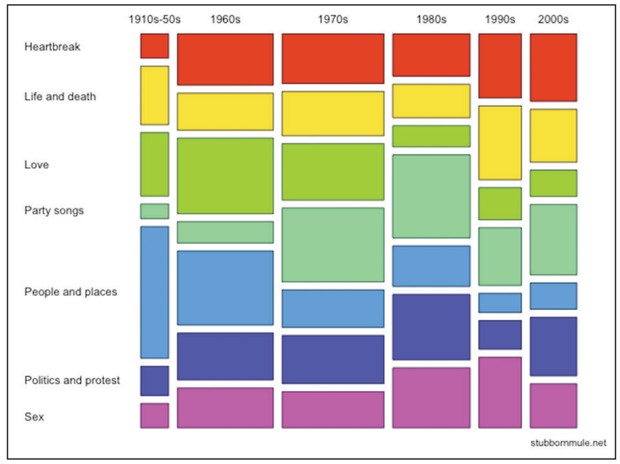


**Figure 2.7**
A mosaic plot technique example (from Sean Carmody, "Mosaic Plot Showing Cross-Sectional Distribution through Time of Different Musical Themes in the *Guardian*'s List of '1000 Songs to Hear Before You Die,'" *Wikipedia*, s.v. "Mosaic plot," last modified July 24, 2009, https://en.wikipedia .org/wiki/Mosaic_plot#/media/File:Mosaic-big.png).

cross-sectional distribution through time of different musical themes in the *Guardian*'s list of "1000 songs to hear before you die."[27]

A visualization technique similar to the mosaic plot is a treemap. Treemaps are ideal for situations in which large amounts of tree-structured (or hierarchically structured) data need to be visualized. The space of a treemap is first split into rectangles, which are sized and ordered based on a quantitative variable. The levels in the hierarchy of a treemap are captured with the visualization of nested rectangles.[28] For example, a rectangle representing a country may contain several rectangles representing states in that country. Each rectangle representing a state may in turn contain rectangles representing cities in these states. A number of different algorithms can be used to determine how the rectangles in a treemap should be sized and ordered, taking into account the general rule of treemapping. In general, the rectangles in the treemap range in size: the largest rectangle will be placed in the top left corner, and the smallest rectangle will be placed in the bottom right corner, with everything else in between placed in the middle part of the treemap. Hierarchies are presented when the rectangles are nested.

Another widely adopted and useful visualization technique is that of *parallel coordinates*. Parallel coordinates are one of the most famous visualization techniques and among the most common subjects of academic papers on visualization.[29] While one's initial impression of parallel coordinates may be that they are confusing, once they are understood it is easy to see why they are a very powerful tool for understanding multidimensional numerical data sets. How parallel coordinates work can be best explained through an example. Figure 2.8 shows an example of parallel coordinates in which the relationships of car variables are captured, including mileage per gallon (MPG), number of cylinders, horsepower, weight, and the year they were introduced.[30] In this visualization, each of the car variables is mapped onto a vertical axis. As a result, each data value falls within some place on the line and is scaled to lie between the minimum at the bottom and the maximum at the top. And for each case in the row, data points are connected and form the polylines. Useful insights can be gained from this visualization. For example, the cylinders' axis is worth noticing because it has only a few different values. And since the number of cylinders can only be an integer, and there are only eight values in this example, all of the lines will go through a small number of points. In the space between MPG and cylinders, one can tell that eight-cylinder cars generally have lower mileage than six- and four-cylinder ones.

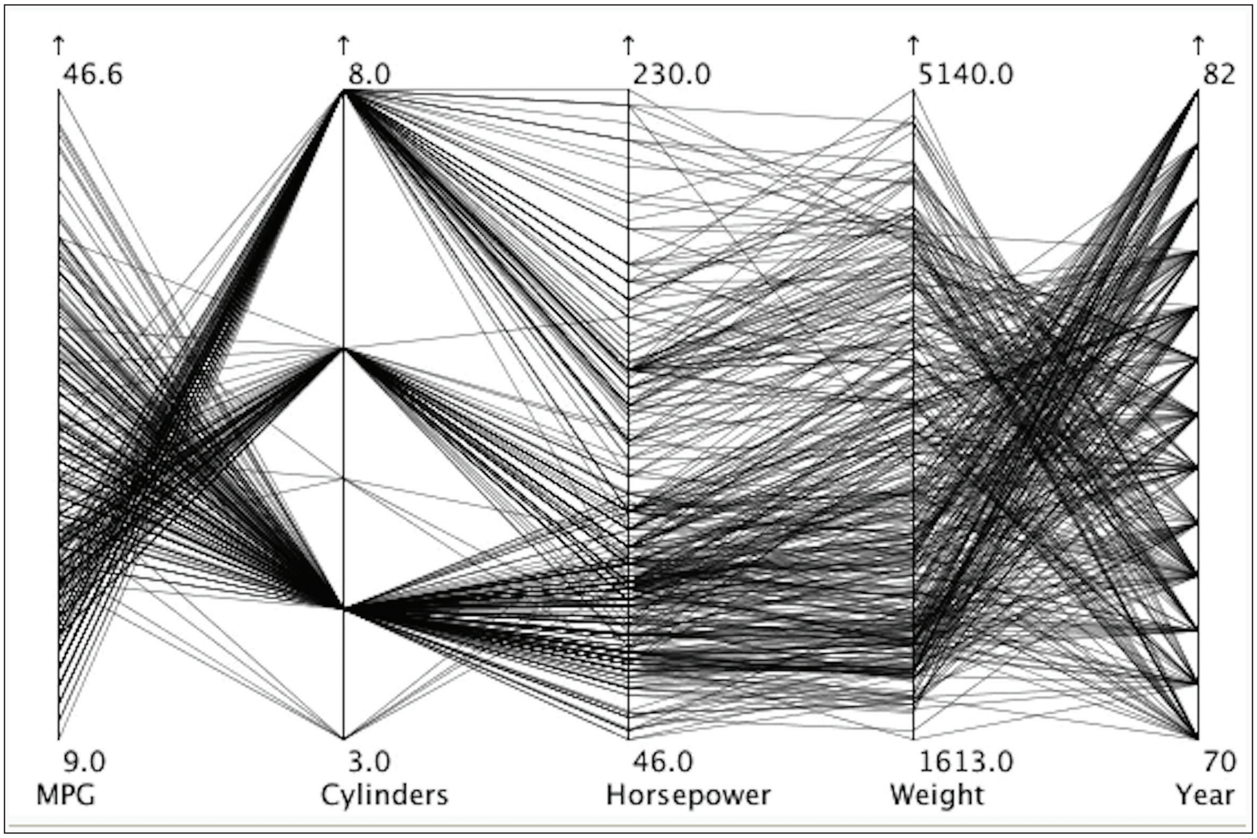


**Figure 2.8**
Parallel coordinates visualization of car variables (from Robert Kosara, "Parallel Coordinates," EagerEyes, May 13, 2010, https://eagereyes.org/techniques/parallel-coordinates).

The "look" of the lines—that is, how they cross and how they fold—can tell more than just the data. For example, heavy crossings of lines are indicators of an inverse relationship; for instance, the more cylinders, the lower the mileage. A similar correlation can also be found between cylinders and horsepower: the more cylinders, the more horsepower. There are also some crossing lines that show that more cylinders do not always mean more power; however, the general trend is clearly there. Between horsepower and weight, the situation is similar: more horsepower means heavier cars in general, but there is some spread in the values. One can also see that there is a single exception of a high-horsepower eight-cylinder car that is very light. Finally, the lines between weight and year heavily cross, which implies that cars have gotten lighter over the years.

## Software

Information visualization is employed in many cases to answer a question, communicate information, support decisions, and increase efficiency. Good information visualization software is important since it improves the audience's understanding of the information being presented. The audience has a higher likelihood of retaining the information, compared to information they receive without visualization. The data visualization engages the audience, and this makes the presentation more interesting. By relaying data to the intended audience in the shortest time possible, presenters also benefit. They do not need to use excessive energy explaining the data to support their message. The use of information visualization software also assists in promoting the credibility and trustworthiness of the data being presented to the audience.

This section provides a list of popular software tools with the objective of encouraging readers to research these tools and give them a try. Through these efforts, readers can connect with the software that best suits their specific needs and preferences.

- **D3.js:** The full name of D3.js is "Data Driven Documents." The software combines HTML, CSS, and SVG to render charts and diagrams. D3.js is well known for its power and flexibility to create very specific, creative visualizations. It is also packed with features, interactive, and extremely beautiful. D3.js is free and open-source, which makes it a great tool for amateur learners.[31]

- **FusionCharts:** FusionCharts is well known for its exhaustive collection of charts (90+ chart types) and maps (over 1,000 maps). FusionCharts supports major data formats, such as JSON and XML. Charts can also be exported into a variety of formats, such as PNG, JPEG, PDF, or SVG.[32]
- **Google Charts:** Google Charts uses HTML5 and SVG to create charts that are portable and compatible across different browsers and platforms. It offers a wide range of chart options, such as bar, pie, line, map, and gauge charts. It is also well known for its flexibility and ease of use.[33]
- **Dygraphs:** Dygraphs is an open-source charting library based on JavaScript. It is well known for its ability to handle large-scale data sets. To accommodate "Big Data," the software is scalable, flexible, and highly customizable. It also has an active support community, which is a great resource for visualization learners.[34]
- **Tableau:** Tableau is one of the most popular, commonly adopted visualization tools. It supports a wide range of charts, maps, graphs, and other visual designs. It also offers strong support for use for academic purposes.[35]
- **Infogram:** Infogram is a software tool that provides the capability to create both charts and infographics. It has a user-friendly interface and well-designed basic charts.[36]
- **Plotly:** Plotly provides a web-based interface for data analysis and visualization. It supports a wide collection of chart types and provides social sharing features. The visualization creation process is intuitive, from loading the data to customizing a visual display.[37]
- **IBM Watson Analytics:** IBM Watson Analytics offers the benefits of advanced analytics without the complexity. It's a smart data discovery service available on the cloud, which guides data exploration and automates predictive analytics, while also enabling effortless dashboard and infographic creation.[38]

## Conclusion

Through the rapid changes of information visualization that have taken place over the decades, the ability to create compelling, visually stimulating content that can be represented with a variety of techniques is greater than it ever has been. Through dedicated efforts, researchers, scholars, and practitioners have developed visualization theories, techniques, software tools, and applications that can be used for a great variety of purposes and can be directed toward target audiences in a compelling way. In order to take maximum advantage of these discoveries and techniques, it is important for visualization learners to be open-minded, constantly seeking new knowledge and skills while keeping up with trends and changes.

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# Information Visualization Meets Libraries

## The Landscape Transformation of Library Data

The White House's Big Data initiatives and policies that were launched in 2012 are responsible for some of the biggest changes in regard to data and libraries in the past several years.[1] This change in the policy landscape has placed a greater emphasis on public access to the results of research funded by the federal government. For example, National Institutes of Health (NIH) policy requires full text of research written as a result of NIH funding to be deposited in PubMed Central within twelve months of publication.[2] A similar momentum to share data has also emerged in academic libraries. For example, Harvard Library made the information on more than twelve million books, videos, audio recordings, images, manuscripts, maps, and more from its seventy-three libraries public. According to David Weinberger, former co-director of the Harvard Library Innovation Lab, "This is Big Data for books. There might be 100 different attributes for a single object."[3] With such an abundance of information at people's disposal, it is now more feasible to create informative visualizations to help analyze Big Data and gain vital insights, such as creating visual timelines that show when publications became broadly cited or maps that show locations of different incidents. Harvard Library's action pioneers an effort that will hopefully encourage other libraries to do the same thing and begin allowing public access to the metadata on their volumes. This has the potential to be the start of a large and unique repository of intellectual information. As a result, data can continue to grow and expand, and information visualization is one of the emerging technologies that can enable a better analysis and interpretation of Big Data.

One other movement that has taken place is that, through the emergence of new technologies that help harness data, various businesses are also increasingly using data visualization for the analysis and processing of large amounts of data. While exciting, this development has raised a new question: What does information visualization mean to libraries? The answer is quite simple. Information visualization provides libraries an opportunity to determine how they can best deliver relevant content to their users through its implementation. The main importance of information visualization from a library's perspective is how it allows the library to leverage all its data in such a way that the data best serves the needs of its patrons or users.[4]

It is not just the patrons who will benefit from the implementation of information visualization in libraries; librarians will also reap benefits. For example, Sarah Murphy of Ohio State University wrote a highly comprehensive and compelling article on what information visualization means to libraries. In this article, Murphy stated that information visualization is important for librarians, especially those tasked with assessment, marketing, and other tasks that require seeing and understanding data. With the help of information visualization, librarians can leverage large amounts of data that were once impossible to efficiently access and manage. Murphy added that with the help of information visualization, librarians can craft beautiful yet informative depictions of data that can help them examine everything from the depth of their collections on a particular topic to the use of their e-resources.[5]

In Carrie O'Maley Voliva's article discussing the importance of information visualization to libraries, she states that information visualization is as beneficial for the staff of libraries as it is for their patrons.[6] Voliva adds that information visualization not only makes data more accessible to everyone who works at the library, but it also helps create transparency across the organization. This is because everyone in the library is able to become a part of decision-making processes.

## The Driving Forces

A lot of researchers have identified different driving forces for libraries to assist them in the implementation of information visualization strategies. The changing nature of the library collection, in conjunction with the rapid changes in technology, is one of the major driving forces that necessitates information visualization in libraries. For example, Rick Anderson predicts that research libraries are going to begin operating in an environment marked with less funding and more competition.[7] Anderson adds that in the future, libraries will also have a lot of expanded options that will help them provide access to high-quality resources. He also notes that in order to deal with this changing nature of the library collection, libraries will have to rethink the ways they build collections.

The driving force that necessitates information visualization in libraries can be best explained in the words of Jannette Finch and Angela Flenner. In discussing the example noted in their study, they state that "the library collection of today is affected by many factors, such as demand-driven acquisitions, access, streaming media, interdisciplinary coursework, ordering enthusiasm, new areas of study, political pressures, vendor changes, and the individual faculty member following a focused line of research. If libraries do not allocate based on data, then there could be subjective distribution of funds, affecting the perception of fairness and damaging the library's reputation on campus."[8] This is an important consideration that must be addressed in today's world.

Another one of the major driving forces behind implementing information visualization in libraries is its ability to increase the library's value to its end users. By delivering information to users in an easy and timely manner, libraries can enhance the way users perceive the library. In Martha Kyrillidou's work, she indicates that the main aim of research libraries goes beyond just collecting, analyzing, and reporting data. It also includes improving their services.[9] According to Kyrillidou, the use of information visualization in libraries not only helps in gathering and evaluating data, but also helps libraries serve their end users better at low administration costs.

Another major driving force that necessitates the use of information visualization in libraries is the increase in the number of e-resources. An additional insight in Kyrillidou's article is that libraries spend a large amount of money to purchase licensed e-resources.[10] Kyrillidou indicates that with the use of information visualization, libraries can easily reduce the cost of purchasing e-resources. The example she offers is how information visualization helps libraries identify their users' behaviors about the use of their e-resources while also helping them track the usage of e-resources at a deeper level. Information visualization can help assess what motivates users to access particular e-resources. This feature of information visualization, according to Kyrillidou, can help libraries cut the cost of purchasing e-resources as they help library staff make informed resource renewal decisions. This is important especially because, as Rick Anderson pointed out, considering the changing nature of the digital collections, there is no need for libraries to purchase online resources before the need arises, as they can easily purchase online resources at the point of use.[11]

An additional bit of insight comes from an article by Mitchell Dunkley of De Montfort University, where he states that information visualization saves a lot of library staff time, especially content delivery staff members who are often assigned the duty of identifying and analyzing user behavior.[12] In his example, Dunkley adds that information visualization not only helps the content delivery staff to make better resource renewal decisions, but it also eliminates the need to manually access and download journal usage reports from the sites of individual publishers. This process thereby saves time for the staff members who are responsible for content delivery, which is beneficial because they can use their time for other productive work.

Apart from these reasons, other factors related to research, such as the need to make all data related to research open, shareable, and reusable, has led to the need for information visualization to become mandatory for libraries to implement. For example, Annarita Barbaro's work states that researchers in Northwestern Mutual's Advanced Planning Library face several challenges in developing data policies.[13] These challenges include the collection and arrangement of information in a way that will help researchers easily retrieve said information and use it in the future as necessary. Barbaro also notes that these data policies affect the core roles of librarians and that librarians have all the necessary competencies to support researchers in every stage of research. In other words, Barbaro states that there is a great need for libraries to develop services that can help researchers create, collect, manipulate, store, and preserve data sets. Another point that Barbaro adds is that with the help of information visualization, libraries can bridge the gap between research needs and library services by helping researchers "clean" data for analytic use. One other notable observation from Barbaro is that providing researchers open access to information also provides an opportunity for libraries to play an integral role in the research process.[14]

## Trends and Practices

The major trends and directions involving the intersection of information visualization and libraries are mainly focused on ensuring that libraries and librarians understand the emergent needs of information visualization. Libraries must focus their efforts on practical applications of information visualization that will help them gain valuable insights to make important decisions, such as selecting resources to renew. Because of these results, a clear path has been paved that will allow for stronger and more effective research on how information visualization in libraries can benefit the creation of open educational resources, which are viewed positively by both faculty and students, as these resources are contributors to student success. This contribution is mainly due to the creation of open education resources, which are able to bring together huge scholarly records from different subject areas.

Aside from information visualization benefiting libraries through the creation of open education resources, current trends also indicate the need to find different information visualization techniques that can provide best results to libraries and their end users. For example, Ryan Womack of the State University of New Jersey states that the implementation of information visualization should not be an end in and of itself for libraries.[15] It is important for libraries to compare different information visualizations to develop an understanding of which visualizations provide the best results. Hence, future trends call for experimenting with different information graphics that use different tools and provide different results, which can maximize the benefits offered by data visualization in libraries.

Womack is not alone in his assessment. Angela Zoss of Duke University agrees and states that as information visualization becomes increasingly embedded in library assessment and outreach, it is important to consider the perspectives of audience and design visualizations that are easy to interpret.[16] Zoss adds that even though there is lot of research conducted on information visualization, research on what type of information visualization techniques can help visually communicate archival context and content in a better manner is lacking. This is why she states that there is a need to conduct more studies on measuring the utility of the existing information visualization techniques, especially those that are used to communicate archival context and content from the perspective of library users.

Apart from benefiting libraries and researchers, there is a stream of trends and directions investigating how implementing information visualization in libraries can contribute toward student learning. For example, a number of studies in the wider literature of library and information science investigate how information visualization intersects information literacy. In addition to considering the fact that an increasingly higher number of students are now exposed to data and information science, there is a quest in the literature on how information visualization should be integrated into general education. There is a belief that the intersection of information visualization and libraries could help expose students to fundamentals of information visualization in general and information literacy in particular.[17] It has been acknowledged that more research is needed on how libraries and librarians can contribute toward development of the information literacy standards among students. Similarly, in a study by Hattwig and colleagues, they indicate that in today's world, where students live in a visually rich environment, it is important for students to develop relevant visual literacy skills.[18] The authors state that libraries can contribute to student learning in the area of visual literacy when they incorporate information visualization into learning. The authors further add that since libraries are often involved in teaching students about the knowledge production process, the field of visual literacy presents an opportunity for libraries to expand their role as partners in student learning. This conclusion is shared by Lauren Magnuson in her book: she agrees and states that "as libraries become more advanced creators of data visualizations, they can play a role in educating their users to become data literate consumers and producers of visualizations."[19]

Another substantial trend stems from a library staff's ability to develop core skills in information visualization. For example, as Womack points out, considering the growth in the quantity of data and technologies supporting that data, library management should consider investing in the development of core skills that will help their staff make the best use of information visualization.[20] In considering the benefits that information visualization provides with regard to presenting, interpreting, and using information, Womack stresses the importance of libraries leading the data information literacy process. In fact, Womack notes that since more and more students are now exposed to information visualization, students should be provided with training from library staff that will equip them to better understand not just information visualization but also the world around them. In order to achieve this change, Womack notes that librarians and educators should equip themselves with accurate information visualization techniques so that they can successfully instruct students. This development has created an urgent need to conduct research on how libraries can enhance staff knowledge with regard to implementing and using information visualization.

## Conclusion

It is an inevitable trend on the rise that libraries are going to have to create a culture in which staff is trained in information visualization as a benefit to the library as an entity, its staff, and its end users. Not only will this initiative provide staff more time to work on other projects of importance, but it will also enable staff to work with students more effectively, in both an instructional and informative manner. In addition, the purchasing of e-resources allows for greater flexibility and the ability to quickly meet research demands and access information from other institutions, which may be imperative to the end user's work. By having instant access to information visualization techniques, students are also able to benefit from a stronger learning experience through their access to the latest trends, research, and data.

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# Real-World Uses for Information Visualization in Libraries

## Supporting Research by Libraries Using Information Visualization

The first example focuses on a library that provided an information visualization service to its users. The Health Sciences Library at the University of North Carolina at Chapel Hill partnered with Renaissance Computing Institute to build a visualization infrastructure, provide expertise, and create an information visualization service at their Collaboration Center. With this service, researchers gained the ability to consult and collaborate with visualization experts to develop custom applications to analyze data. The center's visualization resources include a display wall with a 10-foot-by-8-foot rear-projection display screen capable of 12.5 million-pixel resolution.[1] This display is vital to the success of the data and the space, as this environment creates opportunities for users to interact with the data in real time. Figure 4.1 shows an example of how the center uses information visualization to aid research on injury prevention.[2] Here, dynamic bubbles present injury rates with GDP per capita for countries in different World Health Organization (WHO) regions. The dynamic features also show how these variables change over the years; for example, a user can select a single country or a group of countries and monitor their trajectory over time. This interactive function plays an important role in enhancing a visualization's user interaction experience: the dynamic features not only allow the visualization to reveal different layers of information embedded within the data, but they also make it possible to address the different exploration interests and focuses from the users. What makes this visualization application valuable is its ability to aid researchers in identifying potential research questions and discovering new research directions by being able to interact with the visualizations. As a result, an opportunity for new collaborative efforts between libraries and researchers has emerged with the reach of research and partnerships becoming almost unlimited and opening up exciting new opportunities. With ease of use, the large scale of data being analyzed, and the clarity of messages being delivered, the major benefit that information visualization provides here is to researchers who are investigating specific topics, such as health care, as it facilitates better understanding of public health and other related issues through analyzing complex, large-scale data. This better understanding does not take place just at a local, community-based level, but also a regional or even global level as shown in this example.

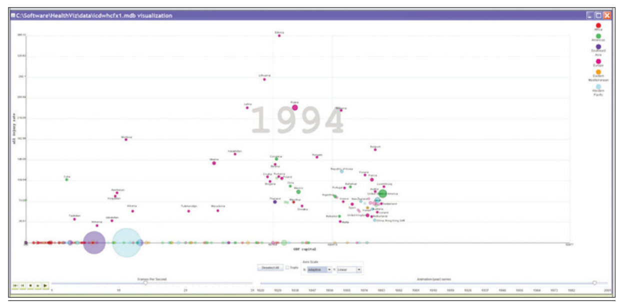


**Figure 4.1**
A visualization application to support research (from Barrie Hayes, Hong Yi, and Andrés Villaveces, "Information Visualization Services in a Library? A Public Health Case Study," *Bulletin of the American Society for Information Science and Technology* 35, no. 5 [2009]: 13–18).


**Figure 4.2**
The "Making Visible the Invisible" commission at Seattle Central Library (from "Fast Facts: George Legrady Artwork at the Seattle Public Library's Central Library," Seattle Public Library, accessed September 26, 2016, https://www.spl.org/Documents/branch/CEN/georgelegrady_art.pdf).

## Visualization Infrastructures to Support Data Understanding

The second real-world case study comes from Seattle Central Library's well-known project "Making Visible the Invisible."[3] In this project, a large, open 19,500-square-foot space was dedicated to information retrieval and publicly accessible computer research. Six large LCD screens were installed horizontally behind the librarians' main information desk, featuring real-time calculated visualizations generated by custom-designed statistical software using data received each hour. This data consists of a list of checked-out items including books, DVDs, CDs, and so on, and visualizations are created using the collective aggregate data. These visualizations serve several important purposes. First, the flow of information can be calculated mathematically, analyzed statistically, and represented visually to showcase the circulation scenarios of the collections in the library. From a community-serving perspective, these visualization snapshots are good indicators of what the community of patrons considers interesting and useful information at any given point in time. Figure 4.2 shows an example of how information visualization was used to reveal checkout patterns from the Seattle Central Library.

## Infographics to Deliver Library Messages

The third real-world application of information visualization applied to a library setting has played an important role in promoting library events and activities and has showed how information visualization can be used to deliver library messages. Figure 4.3 is one of the most widely discussed infographics in the library field—the most controversial books infographics. For example, the *Daily Infographic* features this infographic in its blog post on "the best information design and data visualization from the Internet."[4] Its focus is the display of the most controversial books of 2009. This infographic uses different colored darts to distinguish why books have been challenged by parents. These reasons include if the text contains nudity, offensive language, drugs, homosexuality, suicide, sexism, violence, is sexually explicit, unsuited to the age group, anti-family, or against someone's religious viewpoint. As shown in figure 4.3, most of the books were challenged for more than one reason. Some interesting facts can be drawn from the infographic. For example, according to the infographic, in 2009, whether *To Kill a Mockingbird* handled racism appropriately or not remained a debate. The popular vampire series *Twilight* could not dodge the censorship bullet either, as parents felt it was both unsuited to its target age group and sexually explicit.

## Information Visualization for Storytelling

In another powerful example, we see how information visualization can be used for storytelling and to engage users. Figure 4.4 demonstrates how the storytelling concept can be enhanced through information visualization, as presented by Manav Tanneeru and Toni Pashley from CNN.com at the VisWeek 2010 workshop "Telling Stories with Data."[5] The figure shows the Home and Away project from CNN.com, which presents military casualties in Iraq and Afghanistan.[6] The visualization tool connects the locations of each trooper's birth and death, along with some demographic information. It uses the circles to represent each location. When you hover over a circle with your mouse, it either displays the number of casualties that took place at that location or shows the name of the deceased and highlights the location on the map where they passed away. Further, the visualization is integrated with CNN's iReport platform,

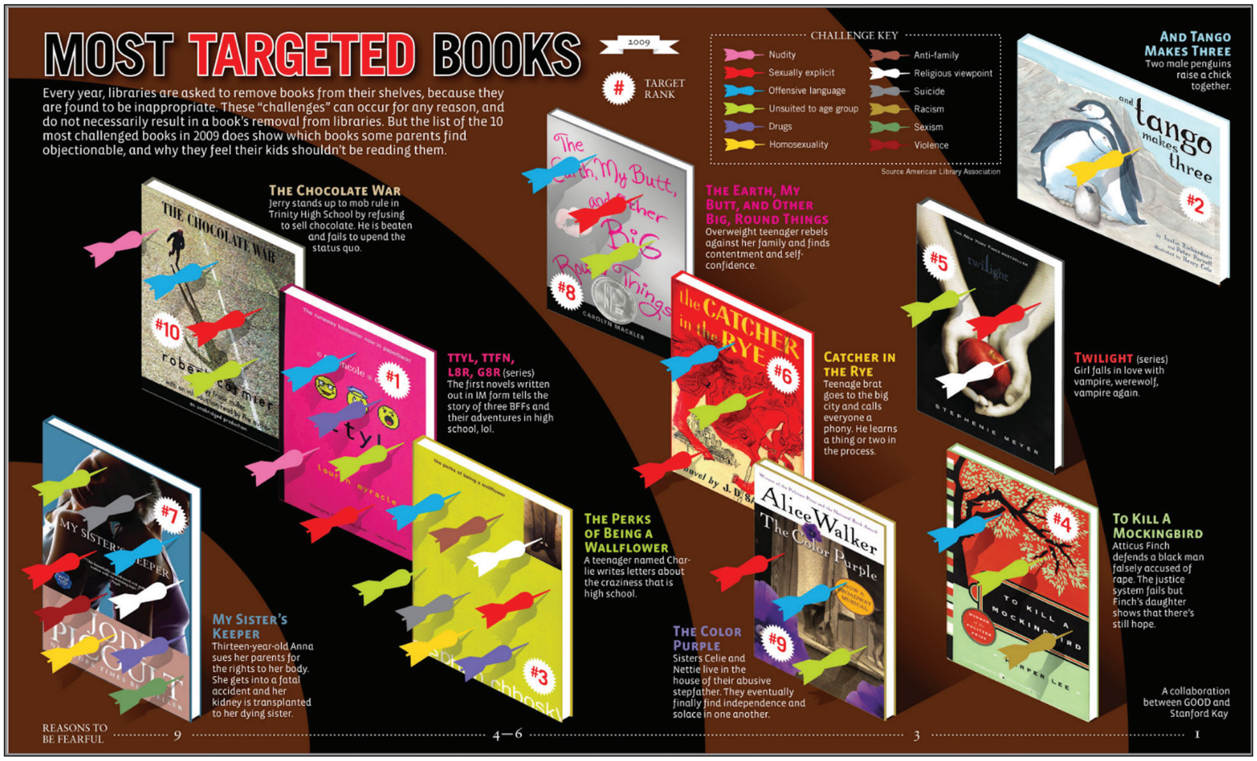


**Figure 4.3**
Infographic for "The Most Controversial Books in America" (from Stanford Kay, "Transparency: The Most Controversial Books in America," GOOD, last modified May 6, 2010, https://www.good.is/infographics/transparency-the-most-controversial-books-in-america).

allowing family and friends of the deceased to tell their personal stories. In this instance, information visualization is used not only as a tool for discovery and data analysis but also as a powerful medium for communication. Clearly, and in a compelling manner, this example shows that information graphics can do more than just present numbers. They offer a medium for individuals to tell their story, engage and convince their readers, and invite them to make a personal connection to the data. This example brings insights into how a library might use its data to connect and engage with the community more effectively by encouraging its patrons to share their stories and experiences with the library through the use of information visualization.

## Information Visualization for Library Data Assessment

Information visualization can also be used for data assessment. Recent research has shown how information visualization could be adopted for library decision making through visualizing library assessment data. For example, Sarah Murphy's work at Ohio State University has been significant in highlighting data assessment.[7] Murphy shared examples of incorporating information visualization into the Ohio State University Libraries' assessment program. In particular, information visualization applications are shown to be used to assess libraries through the metrics of ARL ranking, daily gate count, research services, and many more.

## Information Visualization for Libraries: The Research Perspectives

So far, several real-world use cases of information visualization applications in the library setting have been shown. Much of the research discussed in earlier chapters on information visualization in libraries focused on how it could enhance the interface and user environment, thereby improving activities and user experiences.[8] The research discussed in this chapter is significant because it indicates how information visualization can improve the services that a library offers and the evolution of these improvements through the years. Over the past years, several researchers have attempted to understand how implementing information visualization can help libraries enhance their performance and serve their patrons better. One such attempt was made by Zachary Pousman, John Stasko, and Michael Mateas.[9] The authors state that the use of visualization


**Figure 4.4**
CNN.com's Home and Away Visualization (from "Casualties," CNN, accessed October 25, 2016, www.cnn.com/SPECIALS/war.casualties).

models provides amplified cognition as well as deep insights for expert user populations. Further support for this conclusion is documented in another study conducted by Tanja Mercun and Maja Zumer.[10] This study stipulates that information visualization presents an interactive mechanism for browsing, exploring, and analyzing. The authors further state that these features of information visualization increase people's ability to perform these activities, which in turn helps people to reason from large amounts of information, build new knowledge, and discover and better understand relationships and information space. Mickey Garrison and his peers at Ferris State University published a summary of the benefits of information visualization.[11] According to them, information visualization helps users focus on information that matters the most to them. It extends beyond this as well, also helping users to see patterns, make connections, and draw conclusions from the data. The authors add that information visualization makes the data accessible to all users and not just those who possess advanced analytic skills.

Throughout much of this content, it's been noted that data visualization helps the human brain to process data faster and more effectively than text-based information. This feature of data visualization has helped it grow in popularity, now becoming mainstream to many individuals in the professional and academic communities. It enhances the ability to comprehend and process large-scale heterogeneous collections of data, such as those held by libraries. For example, previous research stated that the different layers of information that libraries contain mainly make it difficult for users to comprehend data.[12] This research also mentioned that the layered information presented by the data, such as heterogeneous collections, adds a risk of getting lost in the details and generalities of the data. However, information visualization or visualizations of libraries can greatly reduce this confusion by enabling the data to be viewed and interpreted at different granularity levels.[13]

To further expand on the perspective of how information visualization helps enhance user experiences, researchers Jeremy Buhler, Rachel Lewellen, and Sarah Murphy stated that information visualization can help libraries produce flexible, in-depth, online dashboards.[14] Additionally, they stated that these dashboards are full of filters and annotations that provide custom visualizations and context. They also mentioned that with the help of information visualization, libraries can blend data from a large number of sources and create dynamic, interactive graphics. This feature of information visualization, according to the authors, simplifies the process of accessing data and makes data easily available to both a libraries' internal and external stakeholders. This research adds another strong support that shows how information visualization can enhance library services and programs through better connecting with its users, stakeholders, and the overall community.

In Lauren Magnuson's book, she agrees and states that providing raw data and nothing else is just not enough.[15] Magnuson emphasizes that it is important for libraries to present data in a way that is understandable, transparent, and compelling. She adds that information visualization helps library users understand data better because it provides context, illustrates trends, showcases patterns, and enables interactive exploration of data.

As far as the benefits of data visualization to libraries are concerned, they extend beyond simply reducing the budget to buy materials. The significance of this can be brought to light from the example that Finch and Flenner show in their work. They state that accurate information visualization in libraries provides avenues for staffing and service, resource expenditures, scholarly relationships, and instructional outreach, as well as providing opportunities for robust collection development.[16]

The use of information visualization in libraries also aids in ongoing management of different programs, such as a device-lending program. For example, in a study by Joyce Chapman and David Woodbury, the role of information visualization in aiding ongoing management of a device-lending program in a library is examined. The authors found that visualization of data of the device-lending program helped in revealing unrecognized patterns in lending.[17] This feature of information visualization, the authors added, helped the staff of the library to not just make more informed purchasing decisions but also to modify systems and workflows in ways that better met the needs of users.

## Conclusion

In order for libraries to stay competitive and remain beneficial to their users, they are now required to understand and invest in information visualization. The benefits of doing so go beyond the budgetary advantages of having less need to purchase resources, such as books, and extend to giving people access to the information they need. Furthermore, the ability to more easily process and interpret data through the use of information visualization is significant in relaying messages and themes and providing an easier-to-understand format to great amounts of information. These progressive, forward-thinking technologies will be essential in paving the way for a stronger future where resources can be shared on a global level as well as extend to even the smallest communities.

## Notes

1. Barrie Hayes, Hong Yi, and Andrés Villaveces. "Information Visualization Services in a Library? A Public Health Case Study," *Bulletin of the American Society for Information Science and Technology* 35, no. 5 (2009): 13–18.
2. Ibid.
3. "Fast Facts: George Legrady Artwork at the Seattle Public Library's Central Library," Seattle Public Library, accessed September 26, 2016, https://www.spl.org/Documents/branch/CEN/georgelegrady_art.pdf.
4. Quotation from Igor Ovsyannykov, "Informative Infographic and Data Visualization Websites," under "15. Daily Infographic," Inspirationfeed, December 6, 2011, http://inspirationfeed.com/inspiration/illustrations/informative-infographic-and-data-visualization-websites/2; infographic from Stanford Kay, "Transparency: The Most Controversial Books in America," GOOD, last modified May 6, 2010, https://www.good.is/infographics/transparency-the-most-controversial-books-in-america.
5. Nathan Yau, "Telling Stories with Data, a VisWeek 2010 Workshop," FlowingData, November 11, 2010, https://flowingdata.com/2010/11/11/telling-stories-with-data-a-visweek-2010-workshop.
6. "Casualties," CNN, accessed October 25, 2016, www.cnn.com/SPECIALS/war.casualties.
7. Sarah Anne Murphy, "Data Visualization and Rapid Analytics: Applying Tableau Desktop to Support Library Decision-Making," *Journal of Web Librarianship* 7, no. 4 (2013): 465–76.
8. Jannette L. Finch and Angela R. Flenner, "Using Data Visualization to Examine an Academic Library Collection," *College and Research Libraries*, forthcoming.
9. Zachary Pousman, John T. Stasko, and Michael Mateas, "Casual Information Visualization: Depictions of Data in Everyday Life," *IEEE Transactions on Visualization and Computer Graphics* 13, no. 6 (2007): 1145–52.
10. Tanja Mercun and Maja Zumer, "Visualizing for Exploration and Discovery," Information + Visualization, 2010, http://infovis.fh-potsdam.de/readings/Mercun2010.pdf.
11. Mickey Garrison, Deb Holdren, Peg Votta, Rosemary Collins, and Robin Taylor, "Data Use through Visualizations and Narratives," *SLDS Spotlight*, National Center for Education Statistics, March 2013, https://nces.ed.gov/programs/slds/pdf/spotlight_data_use_visualization.pdf.
12. Weijia Xu, Maria Esteva, Suyog D Jain, and Varun Jain, "Interactive Visualization for Curatorial Analysis of Large Digital Collection," *Information Visualization* 13, no. 2 (2014): 159–83.
13. Ibid.
14. Jeremy Buhler, Rachel Lewellen, and Sarah Murphy, "Tableau Unleashed: Visualizing Library Data," *Research Library Issues*, no. 288 (2016): 21–36.
15. Lauren Magnuson, *Data Visualization: A Guide to Visual Storytelling for Libraries* (Summit, PA: Rowman & Littlefield, 2016).
16. Finch and Flenner, "Using Data Visualization."
17. Joyce Chapman and David Woodbury, "Leveraging Quantitative Data to Improve a Device-Lending Program," *Library Hi Tech* 30, no. 2 (2012): 210–34.

# Challenges and Concerns

While information visualization presents new and exciting opportunities for libraries to make a better use of their data, it poses major challenges at the same time, such as affordability of new technologies and lack of defined roles for staff. One of the most common challenges for libraries is probably the lack of expertise and skills in information visualization. In their report published by the Council on Library and Information Resources, Lori Jahnke, Andrew Asher, and Spencer Keralis note that information visualization demands the presence of high levels of domain specialist knowledge.[1] They also state that there are no effective ways through which libraries, or other organizations where information visualization can be done, can prepare people to implement and use information visualization. This situation is attributed to a significant shortage in the number of data scientists and other individuals with digital preservation skills in organizations where information visualization can be used and those which could benefit from it. The authors also add that many libraries have varied and even idiosyncratic attitudes toward the implementation of information visualization. From their perspective, this attitude restricts the use of information visualization in libraries.

Despite this restrictive attitude, there is agreement in literature that the lack of expertise or technical skills by people serves as a major hindrance to the implementation of information visualization in libraries. For example, research by Deborah Vincent, Marie Hastings-Tolsma, and Judith Effken states that since the process of information visualization is both technically complex and highly challenging, it requires high technical proficiency.[2] This is where the greatest challenge lies for many libraries. In the authors' study, they found that for many library users, staff in particular, using and exploring information visualization tools may be difficult. This fact makes the implementation of information visualization in libraries a challenging task, partially due to resistance. Therefore, it is important that libraries provide online or real-time training sessions to their staff or, as an alternative, motivate staff members to participate in training sessions that are offered by commercial information visualization software applications.[3]

In another reference, Manguson agrees and states that creating effective information visualization requires a range of skills, such as a thorough understanding of math and statistics and knowledge of data storage, mining methods, front-end design, and development.[4] According to Manguson, these skills can help create better libraries and can allow libraries to offer better instruction and showcase the impact they have on their users and communities. It is important that libraries recognize these hindrances. Libraries must begin investing in their staff to help them develop these skills. By investing in library staff training on the use of information visualization technologies and tools, libraries can benefit both their staff and their end users of library resources. Staff is benefiting by becoming proficient in a new skillset, and end users are finding value in the information visualization resources that the library is creating.

Another major challenge that libraries face in implementing information visualization is the expense. In a survey conducted on the use of data analytics in higher education, Senior Research Analyst Jacqueline Bichsel concludes that high costs of implementation serve as a major barrier to employ information visualization in libraries of educational institutions.[5] She points out that many educational institutions view information visualization as an expensive endeavor rather than as an investment. Apart from high cost, Bichsel also identifies access and standardization of data and culture of educational institutions as some of the barriers toward implementing information visualization in libraries. Data types and availability are constantly changing, making it difficult to design an information visualization platform that is compatible with all sorts of data and analytical needs. The interplay between the culture of educational institutions and analytics can also be a key barrier if, for example, there is a lack of data use regulations. These challenges, on the other hand, shed some light on the strategies that libraries might develop or key areas to focus on if they plan to commit to implementing information visualization in their institutions.

## Conclusion

As incredible as the opportunities that information visualization brings to the way libraries conduct business are, there will be struggles with implementation and use if the proper training isn't in place. In order to be able to employ data visualization, an institution must create opportunities for library staff to learn how to properly use this innovative, game-changing way of retrieving data. From there, a well-trained group of individuals in information visualization are better able to help those they serve.

## Notes

1. Lori Jahnke, Andrew Asher, and Spencer D. C. Keralis, *The Problem of Data*, CLIR Publication No. 154 (Washington, DC: Council on Library and Information Resources, August 2012), https://www.clir.org/pubs/reports/pub154/pub154.pdf.
2. Deborah Vincent, Marie Hastings-Tolsma, and Judith Effken, "Data Visualization and Large Nursing Datasets," *Online Journal of Nursing Informatics* 14, no. 2 (Summer 2010): 1–13, http://ojni.org/14_2/Vincent.pdf.
3. Ibid.
4. Lauren Magnuson, *Data Visualization: A Guide to Visual Storytelling for Libraries* (Summit, PA: Rowman & Littlefield, 2016).
5. Jacqueline Bichsel, *Analytics in Higher Education: Benefits, Barriers, Progress, and Recommendations*, research report (Louisville, CO: EDUCAUSE Center for Applied Research, August 2012), http://net.educause.edu/ir/library/pdf/ers1207/ers1207.pdf.

Chapter 6

# Additional Resources and Final Remarks

As we learned about how information visualization impacts and interacts with libraries, every individual and affected party to this profound undertaking should make concerted efforts to learn the process involved. Thankfully, today there are many learning opportunities and resources that people can use to gain sufficient information and the expertise necessary to properly use and experience the benefits of information visualization. These opportunities will help people in improving upon the skills they already have, or will help them begin studies in this field with a stronger footing.

Some of the major opportunities and resources that are available for individuals to use to get the necessary training include books that give detailed information on the subject, tutorials that offer in-depth explanations about the process of information visualization, webinars, blogs and websites, and articles and journals written by people who have done intensive research on the topic. The interested individual can also decide to use massive open online courses (MOOCs) to gain enough knowledge to become proficient in information visualization.

In this chapter, the various opportunities and resources at one's disposal will be referenced. The text discusses the specific things to look for to ensure that the resource chosen offers both valuable insight and the required steps to start grasping a fundamental knowledge of information visualization. In addition to the basics, opportunities are available to become more conversant in the knowledge and application that it will take to effectively work with this new way of conducting library business and services.

## Books

A substantial amount of information is available in book form that offers guidance and essential knowledge needed for information visualization proficiency. For those who are just beginning, I recommend starting with books that provide information on data visualization in simpler formats and steps so that one can quickly grasp the material in a short, reasonable period of time. Such books will include the use of simple charts and principles to show how data has been encoded. These texts should inform readers about the fundamentals of incorporating visual attributes, such as color and shape, into information visualization and explain the differences achieved when these attributes are used. As the subject progresses, readers will get to a point where the author explains in detail how information visualizations are designed.

Three exemplary book resources are given below, serving as excellent learning resources for not only beginners but also advanced learners on the topic of information visualization:

- Tufte, Edward. *The Visual Display of Quantitative Information*. Cheshire, CT: Graphics Press, 2001.
- Ware, Colin. *Information Visualization: Perception for Design*. Burlington, MA: Morgan Kaufmann, 2012.
- Few, Stephen. *Now You See It: Simple Visualization Techniques for Quantitative Analysis*. Berkeley, CA: Analytics Press, 2009.

These references are a great starting point for individuals looking to learn more about information visualization. Having a physical reference book available is useful, so that learners can quickly return to the book when necessary for either a refresher or to understand something better at a later time.

## Tutorials

Tutorials are one of the single greatest tools that have led to the success of most research programs. Most tutorials are appropriate for the learning process of a subject, especially when it involves learning specific skills such as programming and design. Many tutorials are now available on the Internet, as well as from other sources, that are highly effective and efficient in helping individuals develop and enhance their abilities.

The one drawback with tutorials, depending on the learning goal, is that most of them do not offer a deeper explanation of the subject. They are more likely to give a general description. They enable individuals to gain a higher level of understanding of the tool or topic at hand. Most often, tutorials are a representation of information collected from books, websites, journals, articles, and even well-written programs. These tutorials are simplified to a form that allows the person going through them to easily grasp the concept without straining or growing frustrated.

When looking to gain a basic amount of knowledge on information visualization, tutorials can be a wonderful choice. Using tutorials to study information visualization allows learners to identify those areas that they need to focus on and those areas that they can easily ignore.[1]

Below are two examples of online tutorials that can help individuals dive deeper into learning information visualization, from both a theoretical and practical perspective:

- D3.js tutorial: https://github.com/d3/d3/wiki/Tutorials.
- Tableau tutorial: www.tableau.com/beginners-data-visualization.

## Online Courses

Due to their convenience, online courses have grown significantly in popularity over the past several years. Most people prefer online courses since they are easy to access, and people can study at their convenience. What draws many people to these courses is their directness. They are straightforward and short, allowing an individual to quickly gain the expected skills being taught without much struggle. A good number of universities and other organizations are now offering these courses, which have allowed many people to gain knowledge on a variety of subjects at a lower cost than in-person classes. Some of these courses are free, and others require a fee. Usually, these fees have been subsidized.

Two good examples of online courses that are being offered on information visualization can be found at the following links:

- DataCamp: https://www.datacamp.com/courses.
- Lynda.com: https://www.lynda.com/Design-Infographics-tutorials/Data-Visualization-Fundamentals/153776-2.html.

The number of sources that can give one access to online courses is vast. Because of this, it is important that the individuals looking to take an online course are able to identify if it indeed does offer the knowledge they are hoping to gain. I recommend that before deciding on a course, individuals should hone in on the skills they want to develop first, and then go online to research the various courses available and look at the feedback provided by previous participants.

## MOOCs

Massive open online courses (MOOCs) are a form of training offered to an enormous number of people over the Internet. Those interested just log in to the website, sign up, and then begin studying until they have reached the end of the course materials. What is very appealing about this type of learning is that it is often free of charge. Some of the features one can expect from MOOCs include lecture notes, filmed lectures, readings, and questions. At times, there may be an interactive forum to participate in, which is a wonderful way to enhance the learning experience for all the parties involved. However, overall, these courses are not reliable in comparison to other resources because an individual can misinterpret the information presented with limited direct interactions with the instructor. Some good examples of MOOCs for information visualization include the following:

- Coursera: https://www.coursera.org/learn/datavisualization.
- Udacity: https://www.udacity.com/course/data-visualization-and-d3js--ud507.

As wonderful as a MOOC is for gaining some basic understanding, it is not wise to assume that it is fully accurate, and this is one of the largest substantiated criticisms of this resource. According to Ryan Nelson of UVA McIntire School of Commerce, MOOCs have received several criticisms on their inability to provide sufficient rigor when it comes to offering the best academic strategies.[2]

## Webinars

Webinars are an appealing resource because they are seldom time intensive. W*ebinar* is a short form for "web-based seminar." A webinar involves workshops, presentations, lectures, and seminars that are offered through the Internet, primarily using conferencing software. Several webinars have been offered on the topic of information visualization. These webinars are easy to access, and they require an individual only to register and subscribe to that given website. A good example of a link that requires registration before being able to watch the webinar is given below:

- Qlik—Data Visualization: Best Practices in 2016: http://go.qlik.com/NAM_16_Q1_Data_Visualization_FEB25_Registration_LP.html?sourceID1=web.[3]

Webinars offer flexibility, and they often offer an interactive environment to communicate with presenters and fellow attendees. This format is very appealing. With a webinar, participants can gain the knowledge that they expect.

## Conclusion

Information visualization is a vast topic, and because of increased demand, more opportunities are coming up to enable those interested to gain sufficient knowledge on this topic from a wide variety of resources, which are tailored for different learning styles and abilities. With the information available from these sources, one can easily navigate a pathway to become an advanced expert in information visualization. In addition, it is always a prudent idea to seek out reputable blogs, articles, professional journals, and publications to stay up-to-date on the latest advances in the field.

## Final Remarks

By changing the conversation and beginning to have more in-depth conversations to prepare libraries for the onset of information visualization on a global basis, we can provide library directors and library staff with a better understanding of information technology and its importance. Through these initiatives, these key players will learn how information visualization can be implemented to provide them with data that allows them to better perform their responsibilities and benefit their library staff and end users.

With the use of information visualization, more people are able to understand and process data in a more efficient, streamlined manner. This technology has presented as much interest and excitement as it has challenges, as it is difficult to keep up with the rapidly changing landscape. However, researchers, scholars, and practitioners have dedicated great efforts to training and informing individuals while also demonstrating the usefulness and benefits of implementing information visualization.

Today, libraries are working to create a culture in which staff is trained in information visualization, as it benefits both the work environment and end user. There is still a lot of work to do, but with budgetary priorities shifting from having to purchase physical materials to having to purchase e-resources, it has become substantially easier. By implementing information visualization, libraries have found a way to stay competitive through better research support, data understanding, library message delivery, user engagement and connection, and data assessment. It is an investment that pays off.

Increased acceptance of information visualization comes along with a higher volume of scenarios that showcase data visualization in action, further solidifying why it is the way of the future. The ability to retrieve data and relay it in an easy-to-follow, quick-to-process manner is powerful and effective. Furthermore, it extends the reach of information on a global level, whether in large urban areas or small rural areas.

The largest obstacle to conquer thus far has been training of library staff, but there are many initiatives that now make training easier than it ever has been before. This chapter includes a list of available resources for further training. These resources are helpful at breaking down any remaining resistance and highlight how information visualization will help end users—faculty, students, or professionals who are seeking out data.

What is left to do? It's time to act and embrace these new technologies and understand how they are revolutionizing the ways that libraries conduct business and the services they offer. A lot of progress has been made, and there is still much to do. The time has never been more ideal to take the initiative to incorporate information visualization into the fabric of the library culture.

## Notes

1. "Courses," DataCamp, accessed October 25, 2016, https://www.datacamp.com/courses.
2. Ryan Nelsen, "Best Practices for Killer Data Visualization [Webinar]," *Customer Insights* (blog), Qualtrics, August 4, 2015, https://www.qualtrics.com/blog/4-best-practices-for-killer-data-visualization.
3. "Data Visualization: Best Practices In 2016," Qlik webinar, accessed October 25, 2016, http://go.qlik.com/NAM_16_Q1_Data_Visualization_FEB25_Registration_LP.html?sourceID1=web.

# Notes

# Library Technology
# R E P O R T S

| Upcoming Issues | |
|---|---|
| May/June<br>53:4 | **E-Book Collection Development: A Data-Driven Approach**<br>by Melissa Goertzen |
| July<br>53:5 | **3-D Printers**<br>by Jason Griffey |
| August/<br>September<br>53:6 | **Open Source Platforms**<br>by Marshall Breeding |