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SHOULD WE TEACH DATA VISUALIZATION USING DATA VISUALIZATION STYLE GUIDES?

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ABSTRACT

Brinton (1914) wrote the first 'Design Style Guide' in the form of rules more than 100 years ago, yet no one really studies nor uses them. Organizations like Google and London City Intelligence recently extended their design systems to include standards specifically for data visualization. This speaks to the growing importance of using data and metrics in an organization's decision making and the value of branding them appropriately. In 2014, Amy Cesal created one of the first actual Data Visualization Style Guides for the Sunlight Foundation. Since then, many other organizations have created style guides of their own, however, Data Visualization texts have only recently begun to cover style guides. In this paper we argue that more widespread use of data visualization style guides by organizations would bring consistence brand identity, readability and accessibility to their data visualization work, and that incorporating data visualization into university curricula will be instrumental in encouraging widespread adoption of these style guides.. We present a historical analysis of these style guides from Brinton's 1914 edition to today's examples from 2014 through today to contextualize data visualization style guides for instructional purposes.

Keywords: Data Visualization, Style Guide, Data Standards, Analytics Curriculum

INTRODUCTION

Design Style Guides can be traced back to Brinton (1914) and his seminal Checking List (Table 1.) and Rules for Graphic Presentations (Table 2) in his book Graphic Methods for Presenting Facts. With 55 rules he laid basic principles for consistent, effective, and readable graphics. These rules range from checking data accuracy (rules 8-12), to ensuring readability of axes and labels (13-16), and creating effective legends (22-25). (We can trace the historical influences in today's Data Visualization Style Guides back to Brinton's 55 rules.

Table 1. 1914 Checking List for Graphic Presentations:

CHECKING LIST FOR GRAPHIC PRESENTATIONS	
1. Are the data of the chart correct?	16. Does lettering appear large enough and black enough when seen under a reducing glass in the size which will be used for printing?
2. Has the best method been used for showing the data?	17. Is all the lettering placed on the chart in the proper directions for reading?
3. Are the proportions of the chart the best possible to show the data?	18. Is cross-hatching well made with lines evenly spaced?
4. When the chart is reduced in size will the proportions be those best suited to the space in which it must be printed?	19. Can Ben Day work be used advantageously instead of cross-hatching?
5. Are the proportions such that there will be sufficient space for the title of the chart when the chart has been reduced to final printing size?	20. Do the Ben Day shadings selected have sufficient contrast?
6. Are all scales in place?	21. Are all instructions for Ben Day work given so that it will be impossible for the engraver to make a mistake?
7. Have the scales been selected and placed in the best possible manner?	22. Are dimension lines used wherever advantageous?
8. Are the points accurately plotted?	23. Is a key or legend necessary?
9. Are the numerical figures for the data shown as a portion of the chart?	24. Does the key or legend correspond with the drawing?
10. Have the figures for the data been copied correctly?	25. Is there a complete title, clear and concise?
11. Can the figures for the data be added and the total shown?	26. Is the drafting work of good quality?
12. Are all dates accurately shown?	27. Have all pencil lines which might show in the engraving been erased?
13. Is the zero of the vertical scale shown on the chart?	28. Is there any portion of the illustration which should be cropped off to save space?
14. Are all zero lines and the 100 per cent lines made broad enough?	29. Are the instructions for the final size of the plate so given that the engraver cannot make a mistake?
15. Are all lines on the chart broad enough to stand the reduction to the size used in printing?	30. Is the chart in every way ready to mark "O.K."?

Recently, Rees and Laramie (2019) surveyed the content of data visualization books, but almost none of this material is in the Analytics Body of Knowledge (Cochran, 2018). We propose a research agenda in which data visualization style guides are used to construct an inductive codebook for future content analysis of data visualization. This procedure will allow us to identify salient aspects of effective displays of quantitative information that have endured in industry for decades. What follows here is a review of some of the Data

Visualization Style Guides that have been published since the Sunlight Foundation Data Visualization Style Guide in 2014 and how they relate back to Brinton and his 1914 Rules. We contend that incorporating material from guides of these kind into curriculum for teaching Data Visualization in Analytics or Data Science programs would provide useful pedagogical structure for teaching how to make consistent, reliable and accessible graphics, and help prepare future analysts to be successful in creating the tools needed for companies to make better data based decisions.

Table 2. 1914 Rules for Graphic Presentations:

RULES FOR GRAPHIC PRESENTATION

1. Avoid using areas or volumes when representing quantities. Presentations read from only one dimension are the least likely to be misinterpreted.
2. The general arrangement of a chart should proceed from left to right.
3. Figures for the horizontal scale should always be placed at the bottom of a chart. If needed, a scale may be placed at the top also.
4. Figures for the vertical scale should always be placed at the left of a chart. If needed, a scale may be placed at the right also.
5. Whenever possible, include in the chart the numerical data from which the chart was made.
6. If numerical data cannot be included in the chart, it is well to show the numerical data in tabular form accompanying the chart.
7. All lettering and all figures on a chart should be placed so as to be read from the base or from the right-hand edge of the chart.
8. A column of figures relating to dates should be arranged with the earliest date at the top.
9. Separate columns of figures, with each column relating to a different date, should be arranged to show the column for the earliest date at the left.
10. When charts are colored, the color green should be used to indicate features which are desirable or which are commended, and red for features which are undesirable or criticized adversely.
11. For most charts, and for all curves, the independent variable should be shown in the horizontal direction.
12. As a general rule, the horizontal scale for curves should read from left to right and the vertical scale from bottom to top.
13. For curves drawn on arithmetically ruled paper, the vertical scale, whenever possible, should be so selected that the zero line will show on the chart.
14. The zero line of the vertical scale for a curve should be a much broader line than the average co-ordinate lines.
15. If the zero line of the vertical scale cannot be shown at the bottom of a curve chart, the bottom line should be a slightly wavy line indicating that the field has been broken off and does not reach to zero.
16. When curves are drawn on logarithmically ruled paper, the bottom line and the top line of the chart should each be at some power of ten on the vertical scale.
17. When the scale of a curve chart refers to percentages, the line at 100 per cent should be a broad line of the same width as a zero line.
18. If the horizontal scale for a curve begins at zero, the vertical line at zero (usually the left-hand edge of the field) should be a broad line.
19. When the horizontal scale expresses time, the lines at the left and right-hand edges of a curve chart should not be made heavy, since a chart cannot be made to include the beginning or the end of time.
20. When curves are to be printed, do not show any more co-ordinate lines than necessary for the data and to guide the eye. Lines $\frac{1}{4}$ -inch apart are sufficient to guide the eye.
21. Make curves with much broader lines than the co-ordinate ruling so that the curves may be clearly distinguished from the background.
22. Whenever possible have a vertical line of the co-ordinate ruling for each point plotted on a curve so that the vertical lines may show the frequency of the data observations.
23. If there are not too many curves drawn in one field it is desirable to show at the top of the chart the figures representing the value of each point plotted in a curve.
24. When figures are given at the top of a chart for each point in a curve, have the figures added if possible to show yearly totals or other totals which may be useful in reading.
25. Make the title of a chart so complete and so clear that misinterpretation will be impossible.

Data visualization style guides defined

Definition: Data visualization style guides are standards for formatting and designing representations of information, like charts, graphs, tables, and diagrams. They include what (e.g. types of charts) and why (e.g. reasons for using specific colors). Templates for various tools (like Excel, R, D3.js or Tableau) often accompany a guide to show the how and to make it easy for people to apply the standards from the guide. Data visualization style guides fit within an organization’s larger design system. They include how other guidelines, like brand standards or editorial guidelines, apply to data visualization. For example, they specify how elements like a logo, brand colors, and language tone specifically apply to charts, tables, and diagrams.

Style guides maintain uniformity across different tools and software that produce charts. An organization’s charts should be consistent across tools and look visually similar to the rest of the blog or report it’s part of. Having a style guide with principles and components that work across multiple tools, rather than just one template for one tool, helps achieve this consistency.

Designing for data is a unique challenge. It requires considerable precision and numeracy, but also careful thinking about audience, perception and accessibility constraints. Because the information needs to be conveyed accurately and understood properly, there are additional design constraints when it comes to writing chart titles and displaying connection between labels and data. Styles and colors that may work when applied to illustration do not always work when applied to the density of information data visualization often needs to convey.

EXAMPLES OF DATA VISUALIZATION STYLE GUIDES

To demonstrate the pedagogical value of data visualization style guides, we present a collection of these from a variety of organizations of different types (Cesal 2019). Often these guides are used internally as part of a larger design system, but it’s helpful to look at examples across multiple organizations to understand the component problems that these guides must address. This can be useful to practitioners seeking to create their own guides.

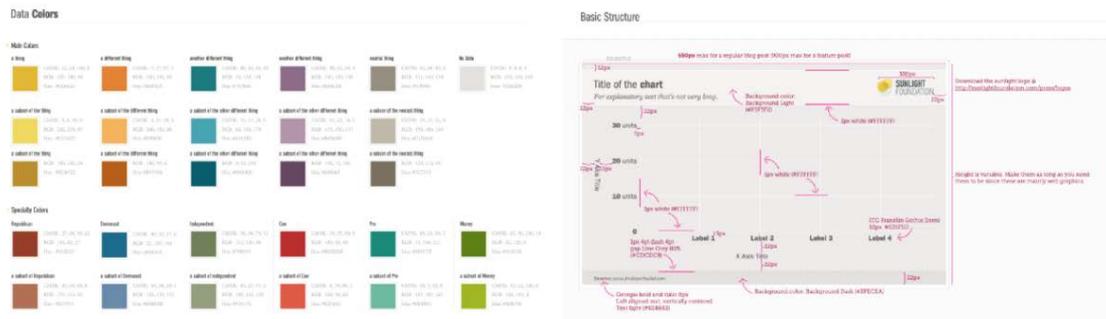
Different types of organizations have different types of information, audiences and needs. We've organized the examples by type, and will highlight especially effective features of each and how they relate to the 1914 Rules (Brinton). Not all organizations release their style guides publicly, although publishing them can help build brand integrity and attract talent. We argue that Universities should be including them in their Analytics Curriculum. Cesal (2019) gathered examples of Data Visualization Guides and a snapshot of examples is presented in Figure 1 and we encourage everyone to investigate and add to the repository. Location TK

URL of guidelines	Company name	Company type	Last updated	Description
https://urbaninstitute.github.io/graphics-styleguide/	The Urban Institute	non-profit		Use this data visualization style guide to create a uniform look and feel to all of Urban's chart and graphs. This site contains guidelines that are in line with data visualization best practices and proven design principles. It also eliminates the burden of design and color decisions while creating charts.
http://code.minnpost.com/minnpost-styles/	MinnPost	news or journalism	2016	Welcome to MinnPost Styles, a super-fly, style guide focused on interactive and news applications made by the MinnData team. A work in progress. MinnPost Styles is a CSS and JS framework. The CSS source is written in SASS and is extendable if you want to include the framework via SASS. The source code can be found on Github.
https://public.tableau.com/profile/bbc.audiences#/?vizhome/BBCAudiencesTableauS	BBC Audiences	news or journalism	2018	Guide for Tableau Desktop users. This style guide is here to help you achieve consistent use experiences, help you make effective visualisations and make your visualisation a part of the high quality output of the BBC's Audiences team.
https://www.ibm.com/design/v1/language/experience/data-visualization/	IBM	for profit	2016	See how IBM uses data visualization to provide meaningful context and precision.
https://style.ons.gov.uk/category/data-visualisation/	Office for National Statistics	government	2019	Guidance for creating charts and tables and best practice for using colour in your work.

Figure 1. Spreadsheet Example of Data Visualization Style Guides

Sunlight Foundation (Non-profit)

One of the first named Data Visualization Style Guides comes from Sunlight Foundation (2014), and was created by Cesal. As you can see in Figure 2, These guidelines specify what colors should be used for (More than Brinton's Red and Green Rule 10 - Table 2) and define particular palates that signify common meanings tended to re-occur in Sunlight's work (for example, colors to use for U.S political parties or pro/con charts). There's also a detailed specification for basic chart structure and how to include branding to ensure that all Sunlight charts were consistent. Brinton (1914) Check List #s 1-25 (Table 1 above) and Rules 1-10 (Table 2 above) are covered quite well as the rules and checklist stand the test of time 100 years later.



Sample pages from the Sunlight Foundation data viz style guide showing what colors are used for and the basic structure for charts

Figure 2. Sample Pages from the Sunlight Foundation Data Style Guide

Cato Institute (Non-profit)

The Cato Institute guide (Figure 3) includes examples of how to most accurately show data visualizations for their audience, and a section on how to implement different types of charts within their guidelines. The guide clearly explains some charting best practices that may not be obvious to everyone within the organization that might make a chart if they haven't had training. Once again Brinton (1914) Check List #s 1-25 (Table 1) and Rules 1-25 (Table 2) are covered quite well in this guide. There are many more chart types than there were in 1914 as you can see in Figure 3.

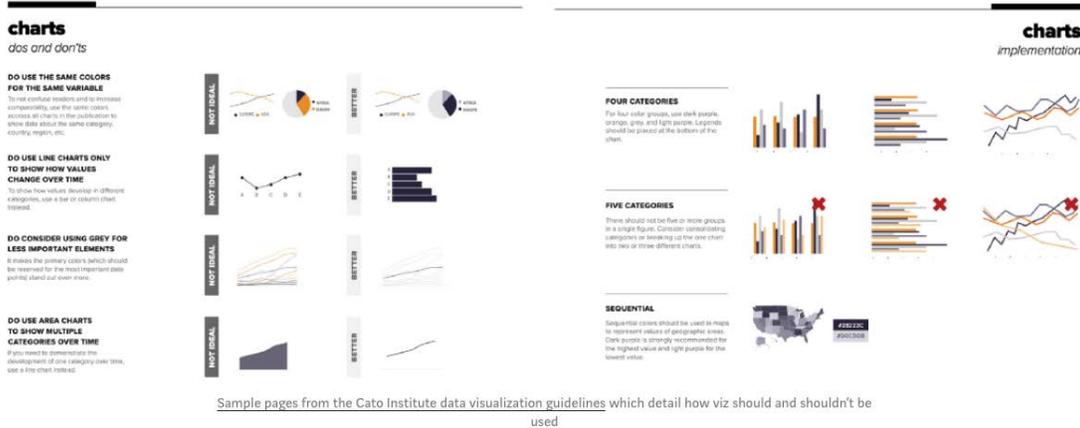


Figure 3. Sample Pages from the Cato Institute Data Style Guide

Consumer Financial Protection Bureau (CFPB) (Government)

This guide (Figure 4) includes how to make charts accessible according to Section 508 of the Workforce Rehabilitation act, which is a requirement for all U.S. government technology. While federal law requires that U.S. government products meet these standards, they provide effective guidelines for data visualizers in all domains. Because of how often CFPB needed to compare projections with historical trends, the guide also included specific instructions on how these categories should be distinguished from each other visually. Brinton (1914) Checking List #s 3-17 (Table 1) and most of the Rules 1-25 (Table 2) will make the charts more accessible and compliant to section 508 as found in this guide. You can see an example of accessibility requirements for <Alt Tags> in Figure 4.

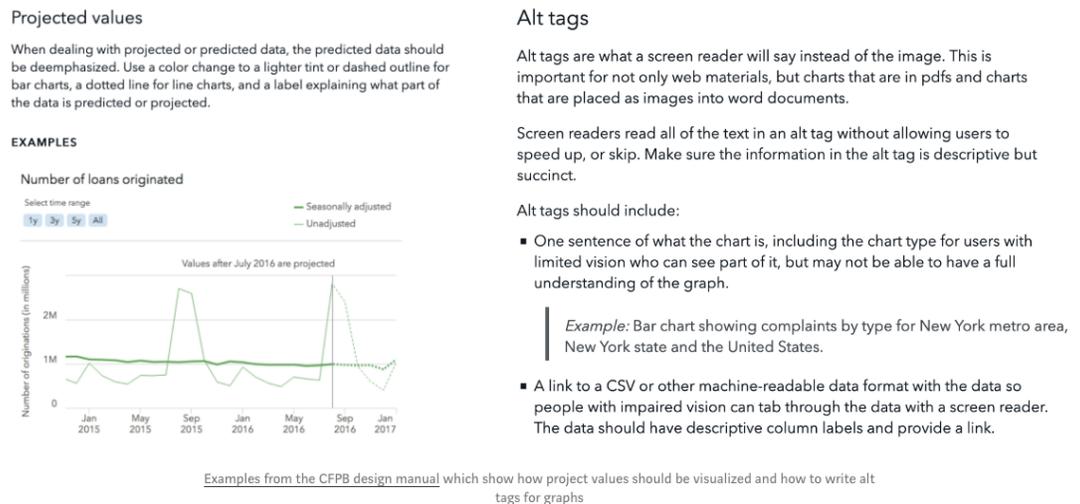
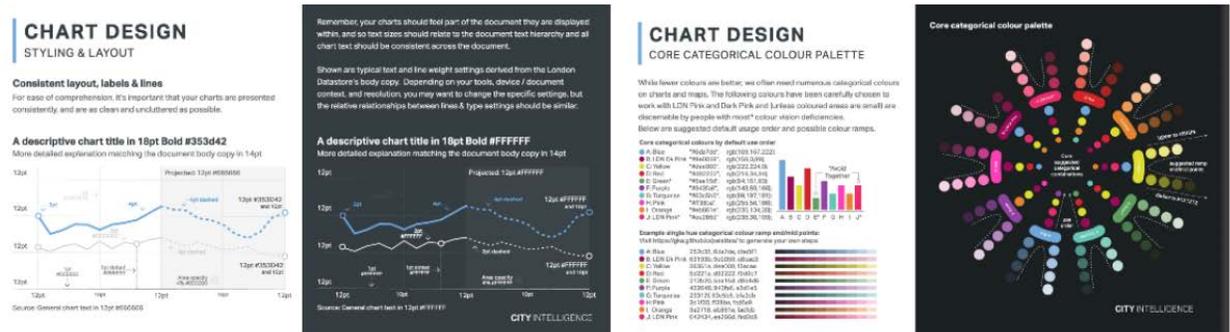


Figure 4. Sample Pages from the CFPB Data Style Guide

London City Intelligence (Government)

This guide dives deep into color choices and why some colors work together and others don't. The guide does a great job of including examples for different types of data (Checking List 2), as well as light and dark backgrounds. Once again most of Brinton (1914) Check List #s 1-25 (Table 1 above) and Rules 1-25 (Table 2 above) are covered quite well in this guide, especially expanding the discussion of color, because of the added complexity of conveying color on a variety of different digital platforms. Examples for chart design guidelines can be seen in Figure 5.



Sample pages from the City Intelligence Data Design Guidelines which show different color schemes for data viz

Figure 5. Sample Pages from the London City Intelligence Data Style Guide

Dallas Morning News (Journalism)

The Dallas Morning News guide includes details about color and style choices for maps to keep the newspaper's displays brand consistent. It also includes a map of how the graphics process works at the organization. A style guide isn't useful if people at the company don't know how to use it properly and work with the system. This guide is a particularly good example of the data visualization style guides as socially embedded documents, which need to be tailored to their institutional context. Once again Brinton (1914) Check List #s 1-25 (Table 1 above) and Rules 1-25 (Table 2 above) are covered quite well in this guide and expands the number of people involved in the process and which rules they should be checking off in the design process. Sample pages can be seen in Figure 6.

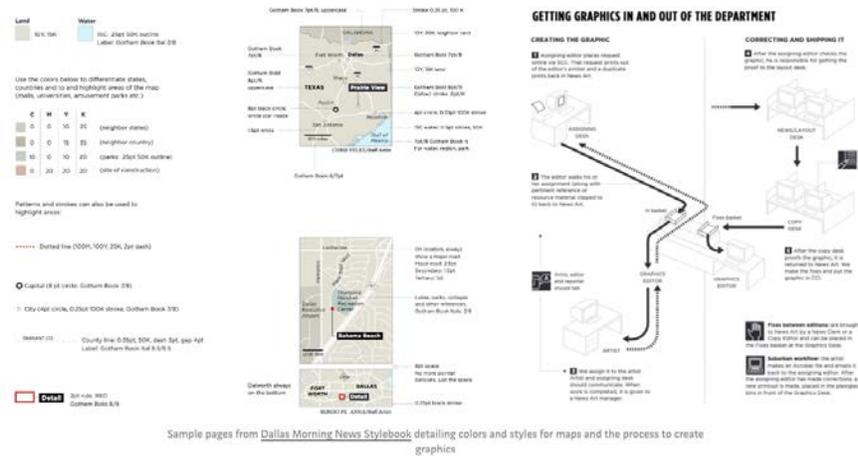


Figure 6. Sample Pages from the Dallas Morning News Data Style Guide

BBC Global Experience Language (Journalism)

The BBC design system has a "How to design infographics" section. Notable points include a variety of examples of labels and a section on how to design responsive graphics that work for different devices (Figure 7). Back in 1914 these visualizations only appeared in print so with the variety of devices they appear on the rules are now adaptable but still in the same categories from the Checking List and Rules (Tables 1 & 2).

Labels

We design labels to be as consistent as possible across the BBC, though we can change the colour and style of label where appropriate.

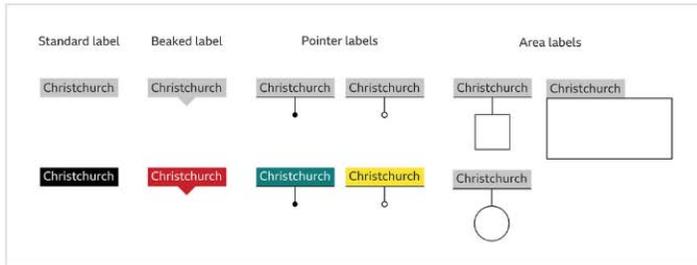


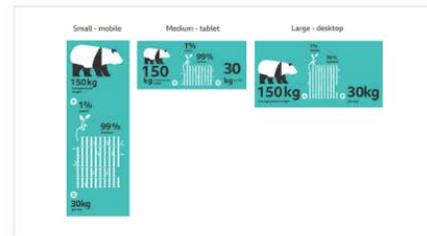
Fig 13 The label styles used in BBC infographics

Responsive infographics

We design infographics to give a good experience across a range of devices and browsers.

Infographics are created at up to three different sizes: small, medium and large. Depending on the size of someone's display, a different graphic will be shown. For example, if you're on a small screen, like a phone, you'll see the small graphic.

To give the best reading experience, infographics have a different layout depending on what size they are. Small (mobile) is presented as a vertical stack while medium (tablet) and large (desktop) have a more horizontal layout.



[Examples from the BBC GEL](#) for types of labels and how to design for different devices

Figure 7. Sample Pages from the BBC Global Experience Language Data Style Guide

Google Material Design (For Profit Company)

This guide has lots of examples of dos and don'ts, with explanations of why the examples work or fail. It also has a section specifically about dashboards with a unique layout for dashboards to help standardize them. Once again Brinton (1914) Check List #s 1-25 (Table 1 above) and Rules 1-25 (Table 2 above) are covered quite well in this guide. In Figure 8 you can see how the guide illustrates the Checking List items 1-5 (Brinton, 1914).



[Examples from Google Material Design](#) for how to use or not use data visualization and how to format dashboards

Figure 8. Sample Pages from the Google Material Design Data Style Guide

IBM (For Profit Company)

IBM's guide includes sections to help chart creators think about who the intended audience is as well as examples of common chart types and what type of data they should be used for. Once again Brinton (1914) Check List #s 1-25 (Table 1 above) and Rules 1-25 (Table 2 above) are covered quite well in this guide with an emphasis on Check List #s 3-18 and Rules 3-18. In Figure 9 you can see illustrated examples of covering Checking List items 3 and 4 (are you using the best charting method with the correct proportions). These will also help with accessibility nearly as well as we saw with the Government Consumer Financial Protection Bureau (2020) Style Guide.

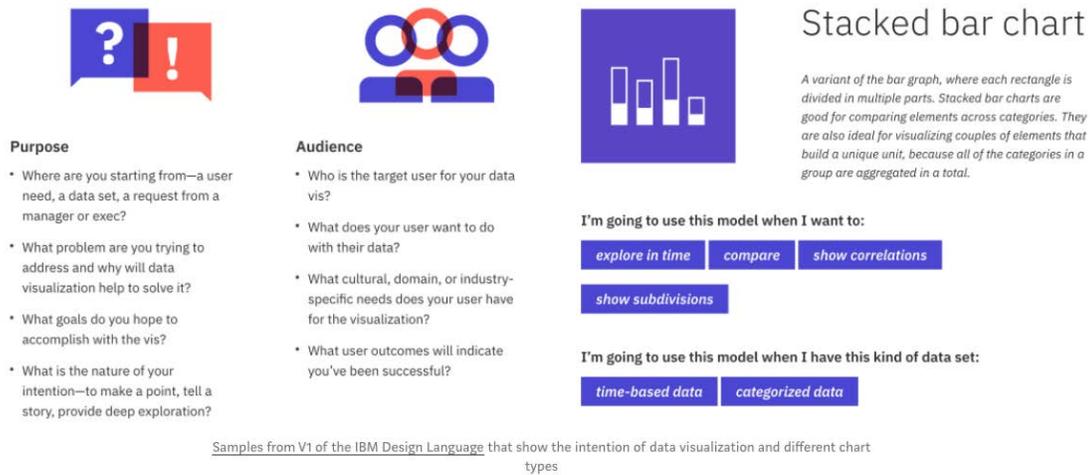
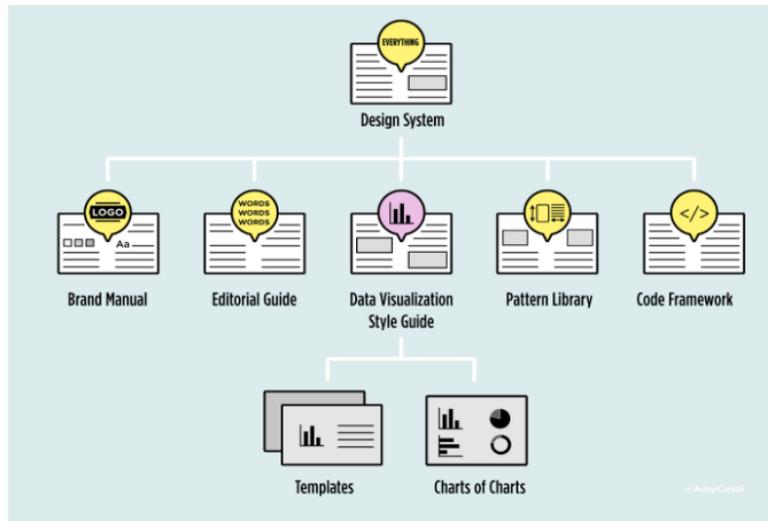


Figure 9. Sample Pages from the IBM Data Style Guide

Other Types of Style Guides

There are many different types and categories of style guidelines. It's useful to be aware of the various types and who uses them to understand where data visualization fits into the broader design system (Figure 10). We can't include them all here but we will show a couple of examples (Figures 11-14).



Design systems incorporate other types of style guides, including data viz style guides

Figure 10. Other Types of Style Guides

Design systems are the full set of standards and documentation for an organization. All the other examples below can live together within the complete design system. They can also include code libraries and packages for developers to build with, as well as design components. The US government has a full design system with many of these systems and UX Pin has an amazing table of design systems that categorizes their components. A data visualization style guide fits into the broader design system. And once again Brinton (1914) Check List #s 1-25 (Table 1 above) and Rules 1-25 (Table 2 above) are covered quite well in the Design System for the Federal Government. Figure 11 illustrates how to implement choosing the correct chart, proportions and dimensions (Checking list items 2 thru 9).

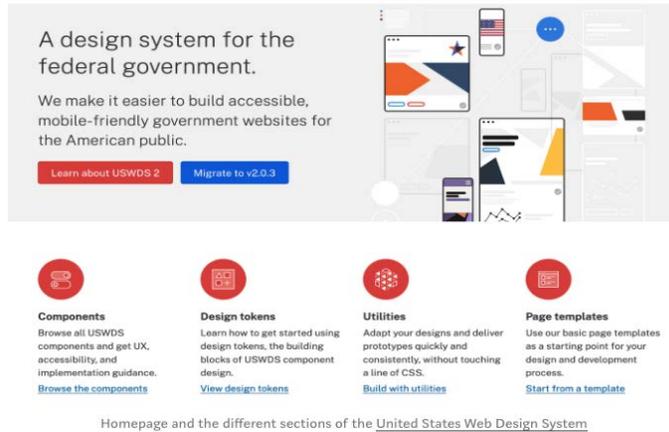


Figure 11. The Design System for the US Federal Government

Editorial guidelines or content style guides define the voice and tone of the brand as well as specific language usage, like how and when to abbreviate or capitalize words. Mailchimp (Figure 12) is a great example of a brand with a consistent unique tone and a thorough guide to accompany it. Editorial guidelines are usually written by content writers and are useful to anyone at the organization or outside contractors and consultants who write or edit anything about the company. Lauren Girardin wrote *How to Create an Editorial Style Guide for Your Agency* specifically for governments, but the content is applicable beyond the public sector. Data visualization style guides pull content from editorial style guides for title and labeling usage. It's helpful to have consistent messaging around errors and how notes or qualifications are worded for clarity. Only a few of the Check Lists (23, 24, 25) and Rule 25 are covered and expanded when combined with Editorial Guidelines and can be traced back to Brinton (1914).



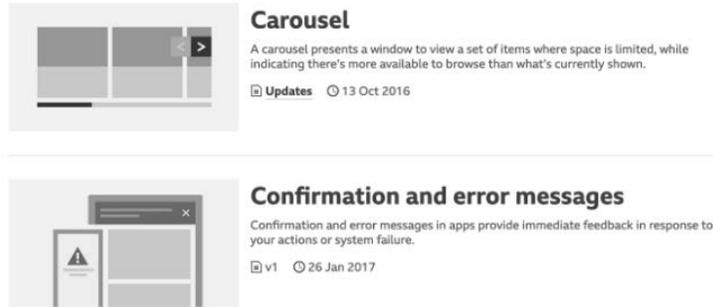
Example from MailChimp's guide on how to properly use abbreviations

Figure 12. MailChimp Example

Pattern libraries document how design elements are used together across a website like specific page types or in navigation. The BBC GEL has a great example in their guidelines. Paul Boag (2017) wrote *How to create a pattern library and why you should bother*, which gives a good overview of pattern libraries and why they're useful for UX. Data visualization is in itself a pattern that has its own set of components like titles, subtitles, charts, data, sources and legends. These all work together to create a visualization pattern. Most of the Checking List and Rules are establishing patterns for data visualizations and would work hand in hand within a Pattern Library. Figure 13 gives you an example of establishing patterns for the legends, keys, titles, and error messages (Checking List 23-26).

Chart taxonomies show a variety of visualization types for specific kinds of data. These can be part of a larger style guide, but on their own don't include enough information to show the specifics of a style and why decisions were made to be categorized as a style guide. Examples include Visual Vocabulary, Chart Chooser cards, Graphic

Continuum poster, and the Data to Viz website. These chart taxonomies could be used as part of a data visualization style guide for an organization and serve to show users how to use specific chart formats. Figure 14 depicts part of the widely used Financial Times Visual Vocabulary which is an example of implementing Checking List items 1-9.



Patterns from BBC GEL that show how components work together

Figure 13. Example Pattern Library



Example from FT Visual Vocabulary of different chart types

Figure 14. Example Chart Taxonomy

SUMMARY

Standardizing data visualization in a guide can help mature this aspect of an organization and allow visualizations to fit into the broader branding and design systems that are already established. Collecting examples of these guides across multiple types of organizations and increasing this collection will show what's standard and useful across this particular type of style guidelines. Very few Data Science or Analytics courses spend adequate time on visualizations, and those programs that do have courses on the topic do not include Data Style Guides. As we have shown in our Historical Analysis from 2014 to present there is plenty of material faculty can use to better teach the theory of Data Visualization by utilizing Data Visualization Style Guides. These style guides will also be more complete if they attempt to incorporate as many of the Checking List and Rules from Brinton (1914). Many of the links for the Figures used here are in the References Section below. In this paper we have identified a critical new method by which practitioners are implementing organization level standards for effective visualization, and demonstrated that these resources are currently underused in the academic and pedagogical data visualization. In future work we plan to gather as many Data Style Guides as we can collect, and perform a content analysis using the Checking List and Rules as our code book. We also encourage faculty to investigate the Data Visualization Society (2020) and Nightingale (2020) as excellent resources for how the theories for visualization design are being applied in industry.

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