CAPTIONS: THE UNSUNG HEROES OF DATA COMMUNICATION

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Data visualization has been recognized as an important tool in communicating data-related findings. Figures often contain a dense amount of information and readers rely on accompanying text to help guide them to the important takeaways. Captions provide the reader with the context needed to interpret visualizations and help tie together the written and visual narratives. Alt-text also plays a role in making the visualization accessible to a broader audience, translating visual cues for those with visual impairments. However, the art of writing captions and other accompanying text for visualizations has rarely been explicitly taught as a companion to the pedagogy of effective data visualization. We describe a variety of classroom activities and assignments that explicitly focus on what makes an effective caption, interpreted broadly, and that build awareness for a variety of audiences for data-related findings.

INTRODUCTION

Data visualizations have been prominent this year, from election maps to COVID case time series, and they play an important role in statistics and data science curricula. The goals for introductory statistics students set out by the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Reports include students being able to create graphs and interpret them (GAISE, 2016). Data visualization is included in the mathematical foundations portion of "Curriculum Guidelines for Undergraduate Programs in Data Science" as they provide a way to communicate results and identify weaknesses in modeling approaches (De Veaux, 2017).

An often overlooked part of a data visualization is its related text, such as captions or alt-text which help situate the graph within the rest of the presented work. Captions connect both the visual and written arguments and narrative. An effective one describes what has been plotted, provides a summary of the findings revealed by the plot, prompts a reader's attention to specific details, and may include details about the production of the plot (see Attachment 1 for an example). Alt-text is an attribute of an image that describes the image. This text is not displayed but is read aloud by screen reader technology that helps those with visual impairments navigate content on computer screens (McEwan and Weerts, 2007). Effective alt-text includes the type of plot, the scale, the variables on each axis, and a description of what the plot reveals in context, e.g. relationship between variables or pattern revealed (see Attachment 1 for an example) (Canelón and Hare, 2021).

Without guidance on how to write an effective caption, instructors may see superficial captions that stop at the "what" element, like "histogram of birthweights," in student projects. Without an introduction to alt-text, students may not even be aware of this attribute of a figure unless they are already familiar with screen-reader use. By helping students better understand the role of captions and alt-text and by giving them opportunities to focus on writing them separate from the task of creating the visualizations themselves, we hope to see more effective textual accompaniment to data visualizations across multiple student outputs.

THE ROLE OF CAPTIONS IN UNDERSTANDING

Captions play an important role in helping readers digest visual information and parse potentially complicated or non-traditional figures. For example, Zhang et al. chronicle the wide variety of approaches to visualizing messages about the COVID-19 pandemic, from more commonplace visualization types like maps and line charts to more novel ones like the Pez chart (Zhang et al. 2021). There is evidence that graphics and subtitles help reading and general comprehension (Gernsbacher, 2015; Guo et al., 2020) and captions affect picture interpretation (Kerrick, 1955, 1959), although they cannot overcome a misleading plot (O'Brien and Lauer, 2018). Captions and other textual labels act as a guide for the reader and help with content recall (Borkin et al., 2016) and takeaways (Kim et al, 2021). Captions also ensure that figures are able to stand alone, without text from the surrounding document. This is especially important for technical articles where readers often skip around,

In: R Helenius, E Falck (Eds.), *Statistics Education in the Era of Data Science*
Proceedings of the Satellite conference of the International Association for Statistical Education (IASE),
Aug-Sept 2021, Online conference. iase-web.org/Conference_Proceedings.php

potentially starting with the introduction, figures, and conclusion before revisiting the denser methods and results sections (Bogucka and Wood, 2009; Raff, 2016; Nolan and Stoudt, 2020).

Students may initially resist the redundancy despite this being an important characteristic of a caption. In the opposite direction, students might be tempted to repurpose phrases from the text into captions. There is a balance that takes practice: captions must add something to the conversation but can repeat key details to orient the reader. Since there is no standard set of guidelines for captions, instructors may want to augment their own requirements with those from the contributor guidelines of journals or other publication venues that are common in their field, e.g., in the sciences (Smith et al. 2016; Biegal and Kamat 2019). This way students can learn about conventions that they may encounter as they go on in their professional careers. By connecting caption writing to norms of writing in their discipline, students will also get experience adapting to space constraints. While writers adapt to figure and page limits, they may find that captions have to also be compressed without sacrificing the core message of the plot.

THE ROLE OF CAPTIONS FOR ACCESSIBILITY

Users may not be able to engage with visualizations for many reasons. Sighted users may face challenges of both visual and statistical literacy when faced with unfamiliar plot types. Captions increase accessibility in terms of comprehension, helping users navigate complex visualizations and noting what they should take away from the plot. Those with visual impairments may have more limited access to data communicated via visualization. Alt-text translates visual context into a form that does not rely on sight. Some of the information in the caption and alt-text may overlap, like what the takeaway message is, while labelling the variables and scales may only exist in alt-text.

Introducing students to alt-text does not have to be a cumbersome task. Logistically, alt-text is supported by software products that may be heavily used already in the statistics classroom (Google, n.d.; Hill et al. 2021). For example, in commonly used Microsoft products, adding alt-text is possible through the formatting panel or via options when a figure is right-clicked upon (Microsoft, n.d.). Instructors may want to move away from the PDF as a final output type; some add-on features allow authors to manually add tags to elements on the page that help somewhat but by default PDFs do not integrate with screen reader technology (Adobe, n.d.; Hewson and Tonkin 2011; Brady et al. 2015). Cesal also provides a straightforward template for those just getting started writing alt-text for data visualizations: "chart type of type of data where reason for including chart (Cesal, 2020). Cesal reminds writers to include a link to the data source somewhere in the text so that a screen reader user can access the data and make meaning of it on their own as well. This reminder to include a pointer to the original data also provides an opportunity to talk to students about open data, data provenance, and best practices for data sharing in general.

CAPTIONS FOR TABLES AND INTERACTIVE VISUALIZATIONS

Captions also play a pivotal role for tables and interactive visualizations and rely on the same principles that apply to static plots. When the numbers themselves are few and most essential, tables may be preferred as a way to provide straightforward accounts of them (Gelman, 2011). An effective table caption describes the source of the numbers in the table, provides a summary of the findings revealed by these numbers, and points readers to the most notable elements or trends in the table.

Captions for interactive plots have to be more nimble to cover a wider range of outputs as readers explore and the visualization changes. Captions, at a minimum, should provide readers with a guide for the interactive elements so the reader knows what they have control over in the visualization. For example, does a slider change the year, does a dropdown menu let the reader change the subset of the data displayed? A more complicated caption could include partially reactive text based on user choices. However, an interactive caption requires a more technical approach and more thought about the structure of accompanying text due to the range of possible user choices. Scrollytelling, where users interactively step through a longer form story, can be seen as an in-between approach where accompanying text changes as the images change in a more controlled way (Amabili, 2019).

CAPTIONS EXIST BEYOND THE PLOT

Once captions and alt-text are given attention in the classroom, both students and instructors start to see them in broader contexts. For example, an art exhibit is made up of visualizations, and

museum labels are their captions, framing what we are seeing as we peruse. There are conventions and guidelines for writing these labels that we can learn from, e.g., Serrell includes "too wordy," "too technical," and "boring" to her list of "deadly sins" of exhibit labels, which hold true as sins of data visualization descriptions as well (Serrell, 2015).

Educators and students have become more familiar with alt-text type services; our increased use of video services to conduct meetings, teach classes, and otherwise socialize with others during the COVID-19 pandemic has made us more aware of the usefulness of video transcripts. Our use of these tools has also made us more aware of the limitations of automatic transcripts, further emphasizing the need to thoroughly add alt-text in our own work (MacLeod et al. 2017). Even when we unwind by watching a movie or television show in a foreign language, we rely on subtitles to translate.

ACTIVITIES

We briefly describe a variety of classroom activities and assignments that focus on what makes an effective caption, with a supplementary goal of making one's data finding accessible to different audiences. We split these activities into three student levels, but each can be adapted for use in classes across multiple levels. By working through a subset of these activities, students practice connecting narrative across visual and written mediums. They also gain an appreciation for being inclusive as they explain their data findings to a wider audience than they may have initially imagined.

For Introductory Students

Instructors can help introductory students experience data visualizations even on day one of introductory courses (Wang et al., 2017). Students can work with pre-existing plots and write captions for them as they learn the fundamental plot types and how to describe distributions.

- Ask students to write a caption for a provided plot, and then compare their caption with a peer. What information did both students provide in their caption? What information differs?
- Pair students together and ask them to write a caption for different plots. Then have their partner sketch their plot using only the caption to go on, compare their peer's drawing to the actual plot, and revise the caption to fill in any gaps that are revealed by this exercise.
- Ask students to respond to the running prompt in the New York Times's weekly "What's Going On in This Graph?" series (New York Times, n.d.). Prompts might include questions, such as "what do you notice" and "what do you wonder", which they answer in caption form.
- Have students visit a local museum and reflect on the displayed labels (e.g., what does the label make you pay attention to?), and then write their own labels for particular items in an exhibit. If possible, talk to those who wrote the labels themselves. We thank the curators at the Smith College Museum of Art and the Phoebe A. Hearst Museum of Anthropology at UC Berkeley for making this possible in our classes.

For Intermediate Students

Instructors can help intermediate students explore plots and captions from other sources and edit the captions to make them more informative for particular audiences.

- Send students on a visualization scavenger hunt in newspaper articles, blog posts, and other internet sources to find examples of plots of different types (e.g., barchart, line chart, etc.) and then write informative captions for each.
- Give students a visualization and caption from a more formal setting (e.g., academic paper) and have them revise the caption for different audiences such as a child, a peer who has not taken a statistics class, or a typical reader of a news media outlet.
- Give students a visualization and have them write multiple versions of a caption as if the figure was being placed in different types of publications (e.g., formal journal article, blog post, tweet, or news story).
- Prompt students to add alt-text to figures with captions. Then, have them reflect on what information is repeated across the two mediums and what information is distinct.

For Advanced Students

Advanced students can create their own plots and write captions for them as part of a final project or report.

- As a preparatory step towards a report of a data analysis, ask students to create a visual outline of the report made up of plots and tables along with their captions.
- Prompt students to use the components of their visual outline from the activity above to go through a storyboard process, a way to visually organize story components, to further refine their argument and story.
- Have students investigate the technology behind alt-text by working through a screen reader tutorial and examining online figures, captions, and alt-text in the developer pane of an internet browser.
- Let students teach one another the tools that support alt-text by assigning small groups to investigate how alt-text is created in a particular software and then present a tutorial to the class.
- Ask students to curate their work from the class as part of a "gallery walk", by, e.g., adding an example of work they are proud of to a slide in a slide deck and providing an "exhibit label" in the notes.

CONCLUSION

It takes time and care to craft a visualization that reveals the desired story or finding, and we advocate for showing students that it requires similar time and care to write accompanying text. The effectiveness of captions and alt-text depend on the context of the broader work and that work's desired audience. The activities described above provide students with opportunities to practice blending visual and written narratives across a range of product types and audiences and to reflect on the similarities and differences between them. We hope that by giving captions and alt-text explicit attention in statistics and data science classes at all levels, students will see them as essential elements of a data visualization, not an optional add-on.

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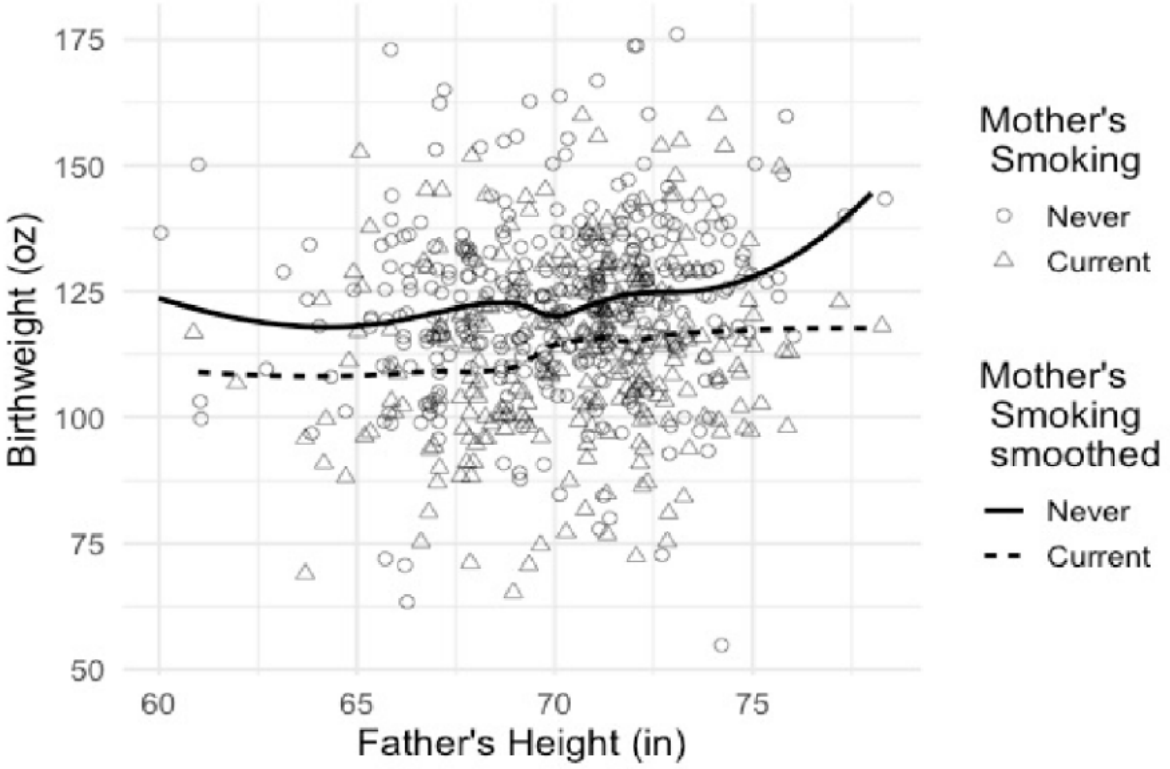

Caption: Father's height and baby's birthweight have a weak, positive linear relationship. The symbols in the scatter plot indicate the mother's smoking status (circle for never smoked and triangle for smoked during pregnancy). The two curves added to this plot show the average birthweight for babies born to fathers with roughly the same height (dashed for mothers who smoked during pregnancy and solid for mothers who never smoked). The relationship between birthweight and father's height is roughly linear for both groups of mothers and parallel, so babies born to never smokers consistently weigh more on average than those born to current smokers.

Alt-text: Scatter plot of father's height in inches on the x-axis and baby's birthweight in ounces on the y-axis. Points are represented by a circle for babies whose mothers never smoked and by a triangle for babies whose mothers smoked during pregnancy. There is a weak, positive linear relationship between father's height and birthweight. Two curves are overlaid on the points representing the average birthweight for babies born to fathers with roughly the same height with a dashed curve for mothers who smoked during pregnancy and a solid curve for mothers who never smoked. These curves show that babies born to never smokers consistently weigh more on average than those born to current smokers. Data can be found at https://www.stat.berkeley.edu/~statlabs/-data/babies23.data

Attachment 1: A sample figure with caption and alt-text. Highlighted in the caption are takeaways such as the weak linear relationship between the variables and how the local average for one subgroup is parallel to and above the local average for the other subgroup. Visual cues are explained, such as the role of different glyphs and line types, and the calculations needed to create the curves (local average) are also explained. The type of plot, the variables, and the units are outlined in the alt-text. Like the caption, aesthetics like shape and line type that map to variables in the dataset are also explained and takeaways are highlighted.