Accessible statistical charts for people with low vision and colour vision deficiency

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ABSTRACT

Statistical charts play a primordial role in different areas of our life, such as information, education, communication or research. However, authors and content publishers do not always follow the accessibility criteria in the design and creation of this type of content. Considering these premises, this work includes the main approaches in which the scientific literature has focused so far to improve the accessibility of statistical charts: text alternatives, sonification, tactile alternatives and multimodal alternatives, with the purpose of evaluating their suitability for people with low vision and color blindness. Finally, some solutions are suggested that seem technologically viable and that start from the use of JavaScript libraries for the creation of interactive charts, in combination with other standards such as WAI-ARIA and the use of patterns to fill areas as a strategy to differentiate visual variables.

CCS CONCEPTS

• Human-centered computing → Accessibility → Accessibility systems and tools

KEYWORDS

Charts, visualization, color blindness, low-vision users

1 Introduction and justification

The important growth of statistical charts, as well as the prevalence of users with low vision or colour blindness requires special attention to be paid to the accessibility to these types of resources as communication elements. Low vision is a distinct visual disability from blindness which cannot be completely corrected with lenses. Colour vision deficiency (CVD) refers to the inability to distinguish certain colours combinations. These individuals present a wide range of characteristics and may use screen magnifiers, screen readers, or colour adaptations.

This research addresses the accessibility of statistical charts for individuals with these profiles. This article includes the first phase of an ongoing research, consisting of a review of the current work and existing solutions, and provides some clues about possible lines of work.

2 Current solutions

The literature offers four different strategies to improve the accessibility of statistical charts: textual alternatives, sound schemes, tactile alternatives and multimodal presentations.

Textual alternatives may consist of: titles, alternative texts, long descriptions, tables and the use of dynamic and interactive visualizations. The title and alternative texts express the content of the chart in a summary manner. They are particularly helpful in identifying the content of a chart. Long descriptions provide the function or information contained in the chart in greater detail. Tables contain the same data as the chart in textual format, however, it is difficult to perceive trends or comparisons between variables in the tables.

Finally, certain software libraries based on Web standards have been designed to create dynamic statistical charts which offer information to the screen readers. SVG in particular allows to enhance images without losing quality and also incorporating ARIA attributes for each of their elements [1]. Two libraries are particularly relevant due to the degree to which they have been adopted: D3[1] and Highcharts[2]. Both have additional modules that implement solutions including patterns, keyboard support,

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[1] https://d3js.org/.
[2] https://www.highcharts.com/.

compatibility with screen readers, they are able to generate alternatives in tabular format, or to use the WAI-ARIA specification. An example can be seen in the following chart,[3] which provides support material for this article.

Beyond the elements specifically created as alternatives, statistical charts can feature other important texts to make them accessible such as legends used to help interpreting the marks and variables used; labels that detail the variables and categories represented; and image captions which include a brief explanation about the chart [2].

Different authors have explored the use of sonification techniques, that represent information through sound, without using voice. In this sense, several techniques have been explored: mapping charts to musical tones [3] and vibrations [4], using sounds to communicate trends [5], using volume, timbre and position to represent quantitative and qualitative aspects [6] or to communicate the shape of a curve [7].

Tactile alternatives are focused on converting digital information into something tangible. Unfortunately, not all people with visual impairment understand Braille and it is also difficult to represent the complex details in charts with precision. This technique also implies being dependent on printers or software which are not available to all audiences.

Multimodality offers users the possibility to access content through one or several combinations based on text, sound and touch. Certain proposals combine tactile alternatives with verbalized information and analyse the use of voice support combined with chart haptic presentation [8]. Yu and Brewster [9] use speech to provide information about the chart's values, while Fritz and Barner [10] also use a light source to present the axes and grid lines.

Regarding the use of colour, Olson and Brewer [11] propose colour schemes on maps adapted for people with CVD. Other contributions have analysed the usefulness of colour for specific tasks [12], to make statistical judgements [13].

The use of different types of visual marks and encodings (position, length, angle, volume and colour) has also been studied [14]. The use of colour has been studied in depth by Mackinlay [15], who classifies attributes such as hue, saturation and luminosity according to their efficiency. Finally, according to Ware [16], colour is useful as a nominal code, whereas the use of grey scale is less effective. Using patterns and textures can also help users with low vision and even for normal black and white printing contexts.

5 Conclusions and future work

Of the four approaches proposed by the scientific community to address the accessibility of charts, textual alternatives and the proper use of other text elements offer highly flexible content that can be adapted to the needs of each user. The use of safe colours,

patterns and textures additionally seem to be effective solutions for people with CVD. All the approaches can be addressed using currently consolidated technological bases in certain existing JavaScript libraries. The possibility to describe the charts' information and the function more thoroughly using WAI-ARIA, implementing secure colour schemes or an appropriate collection of patterns, and finally, creating guidelines that include all these aspects are the main lines of future work.

REFERENCES

[1] W3C (2018). WAI-ARIA graphics module: W3C recommendation 02 October 2018, https://www.w3.org/TR/graphics-aria-1.0/.
[2] Hong Yu; et al. (2009). Are figure legends sufficient? evaluating the contribution of associated text to biomedical figure comprehension. Journal of biomedical discovery and collaboration. 4(1). DOI: https://dx.doi.org/10.1186%2F1747-5333-4-1.
[3] Robert F. Cohen; et al. (2005). PLUMB: displaying graphs to the blind using an active auditory interface. Proceedings of the 7th international ACM SIGACCESS Conference on Computers and Accessibility, 182–183.
[4] Tatiana G. Evreinova; et al. (2008). Non-visual interaction with graphs assisted with directional-predictive sounds and vibrations: a comparative study. Universal access in the information society, 7(1–2), 93–102. DOI: https://doi.org/10.1007/s10209-007-0105-9.
[5] James L. Alty; Dimitrios Rigas (2005). Exploring the use of structured musical stimuli to communicate simple diagrams: the role of context. International journal of human-computer studies. 62(1), 21–40.
[6] K. M. Franklin; J. C. Roberts (2003). Pie chart sonification. Proceedings on Seventh International Conference on Information Visualization. IEEE, Los Alamitos, CA, 4–9. DOI:10.1109/IV.2003.1217949.
[7] Iyad Abu Doush; et al. (2009). Making Microsoft Excel™ accessible: multimodal presentation of charts. Proceedings of the 11th international ACM SIGACCESS conference on Computers and accessibility. New York, NY, 147–154.
[8] Patrick Roth; Hesham Kamel; Lori Stefano Petrucci; Thierry Pun (2002). A comparison of three nonvisual methods for presenting scientific graphs. Journal of visual impairment and blindness. 96(6), 420–428, https://archive-ouverte.unige.ch/unige:47498.
[9] Wai Yu; Stephen Brewster (2003). Evaluation of multimodal graphs for blind people. Universal access in the information society. 2(2), 105–124. https://doi.org/10.1007/s10209-002-0042-6.
10] Jason P. Fritz; Kenneth, E. Barner (1999). Design of a haptic data visualization system for people with visual impairments. IEEE Transactions on rehabilitation engineering. 7(3), 372–384.
[11] Judy M. Olson; Cynthia A. Brewer (1997). An evaluation of color selections to accommodate map users with color-vision impairments. Annals of the Association of American Geographers. 87(1), 103–134.
[12] Danielle Albers; Michael Correll; Michael Gleicher (2014). Task-driven evaluation of aggregation in time series visualization. Proceedings of the 32nd annual ACM conference on Human factors in Computing Systems, 551–560.
[13] Michael Correll; Danielle Albers; Steve Franconeri (2012). Comparing averages in time series data. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 1095–1104.
[14] William S. Cleveland; Robert McGill (1984). Graphical perception: theory, experimentation, and application to the development of graphical methods. Journal of the American Statistical Association. 79(387), 531–554.
[15] J. Mackinlay (1986). Automating the design of graphical presentations of relational information. ACM Transactions on Graphics (TOG). 5, 110–141.
[16] Colin Ware (2012). Information visualization: perception for design. 3rd ed. Elsevier: Morgan Kaufman, Amsterdam.ISBN:978-1-4503-0000-0/18/06

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[3] http://rubenalcaraz.es/graficos/grafico-lineas.html.