Perceptual Mechanisms and Glyph Design

The world we live in today gathers and consumes more data than ever before. To make sense of this information, we create visualizations with markings called *glyphs* or *visual variables*. However, translating multidimensional data into perceptible visual representations can be challenging. It is not sufficient for a glyph to be able to represent multiple dimensions; to effectively convey information, glyphs must also be designed in a way that recognizes the intricacies of human perception.

An understanding of object perception supports better glyph design. For instance, the shapes of glyphs are very important, as shape can bring forth certain memories and associations in a viewer (Ware, 2012). Designers can use this concept to their advantage when creating glyphs that represent particular kinds of data. For example, Fuchs, Fischer, Mansmann, Bertini, and Isenberg (2013) asked participants to read values at specific temporal locations from a number of different glyphs. Some glyphs, such as the *stripe glyph*, represented time linearly, while others, such as the *clock glyph*, represented time as a circular cycle (see Figure 1). The results showed that participants were better able to read values at specific temporal locations when using the circular clock glyph than the rectangular stripe glyph. In essence, participants navigated temporal data most effectively when the glyph looked like an object they would normally use to access temporal information. Thus, the glyph with the more intuitive shape was easier to use.

Knowledge of colour perception can also lead to more effective glyphs. For example, visualization designers should take learned associations into account when selecting glyph colours. Many colours are associated with specific concepts, such as blue being associated with coldness and red being associated with heat (Ware, 2012). Thus, in order to give visualizations perceptual immediacy, the colours of glyphs should coincide with common associations as much as possible. Consider Figure 2(a), which shows a visualization of thyroid cancer cases using pyramids of closely-placed coloured glyphs (Muller, Reihs, Zatloukal, & Holzinger, 2014). The various hues represent different stages of the cancer, while glyphs with black caps represent mortalities (see Figure (b) for a closer look). This design choice aligns with the tendency to associate the colour black with death or absence. Thus, it is perceptually easy to make the connection between the black-capped glyphs and the concept of mortality. This is just one example of how an understanding of colour perception, like object perception, leads to better glyphs.

While knowledge of perceptual mechanisms supports the design of glyphs, research on glyph design can also suggest new knowledge of perceptual mechanisms. For example, there is an emergence of research on the effects of making data visualizations interactive. Saket et al. (2017) specifically investigated how users interact with different kinds of glyphs. Their research illuminates the nature of how people can manipulate visualizations and thus perceive them in dynamic ways. Further research on interactivity with data visualizations could lead to a better understanding of perception. For instance, knowing how a user's perception of a visualization

changes while they interact with it could provide new insight into ensemble coding. Traditional approaches to researching ensemble coding have mainly involved static visualizations. Opening the door to interactive visualizations might reveal greater knowledge about the nature of perceiving entire displays of information at once. Ultimately, observing the many modern ways that people read glyphs and data visualizations could be a promising approach to further understanding human perception.

In conclusion, the relationship between perception research and glyph design is important but not unidirectional. While knowledge of perceptual mechanisms can help us better understand effective glyph design, research on human interaction with glyphs could also illuminate new knowledge of perception.

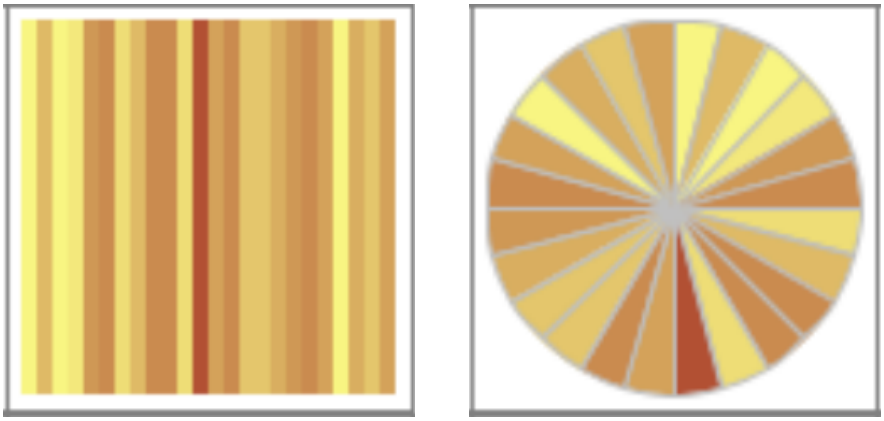
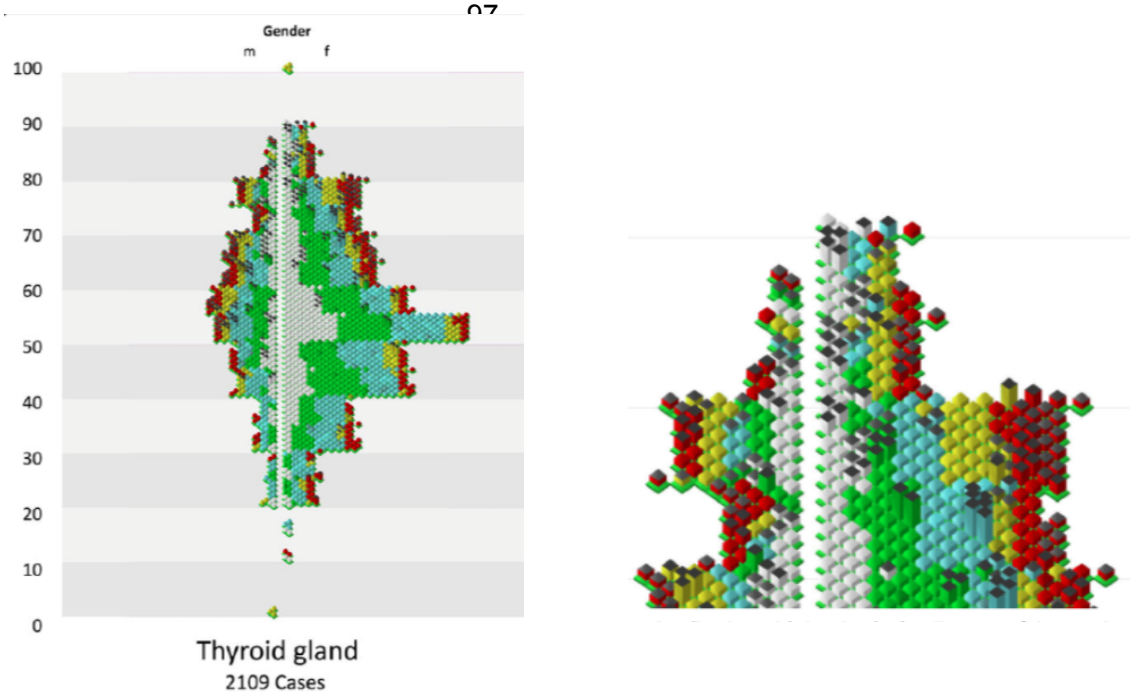


Figure 1. Examples of a *stripe glyph* (left) and *clock glyph* (right) used in Fuchs, Fischer, Mansmann, Bertini, and Isenberg's (2013) study on glyph designs for time series data.



(a) (b)

Figure 2. (a) A data visualization representing patients with thyroid cancer by age and gender, as well as their stage (represented by hue). (b) A close-up of the visualization shown in (a). (Muller, Reihs, Zatloukal, & Holzinger, 2014).

References

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