User Experience (HSEL MIM 20 W21)

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Human perception based data visualisation

- Key aspects to effectifly illustrate information visually

The science of visual representation of data

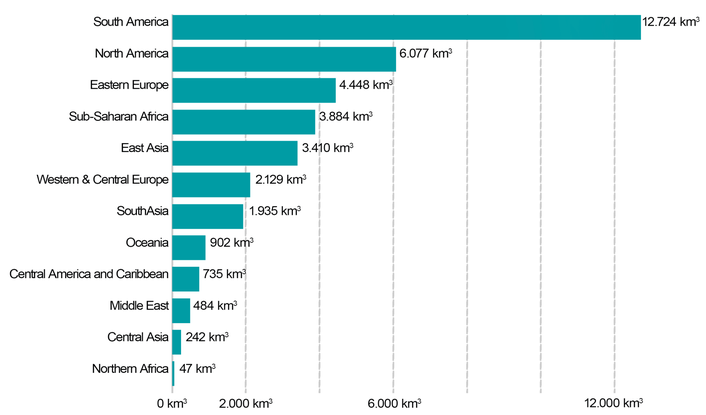
Data visualization is regarded as „the science of visual representation of data“ (*Friendly, 2009, p. 2*). The technology of data visualization has evolved from hand-drawn charts in the earliest stages to using computer technology (*Friendly, 2009*) to analyze and display information. Due to the rising amount of digital data, such as from the internet data flow or from data warehouses, data visualization is now, in the first instance, connected to digital data and computer generated images. Various researchers agree on this idea, that the success of data visualisation is based on the use of computer-generated images to gain insight and knowledge from data and its inherent patterns and relationships. (*Post, Nielson, & Bonneau, 2003*)

Vision perception in the human visual system

Human perception involves signals that go through the nervous system. For example, vision involves light striking the retina of the eye. Data visualization focuses on vision perception, which is the primary human sense. (*Qi Li, 2020*) To find out which key elements work effectively to visualize information for the human visual system, we need to understand how the human visual system perceives data and information. We also need to take into account that human perception has a pronounced psychological component that leads to cognition. Cognition, which is handled by the cerebral cortex, is much slower and requires more effort to process information. Presenting data visually accelerates our perception and helps to reduce cognitive load.

Per capital renewable water resources

Entity	Year	km³
Central America and Caribbean	2015	735
Central Asia	2015	242
East Asia	2015	3.410
Eastern Europe	2015	4.448
Middle East	2015	484
North America	2015	6.077
Northern Africa	2015	47
Oceania	2015	902
South America	2015	12.724
South Asia	2015	1.935
Sub-Saharan Africa	2015	3.884
Western & Central Europe	2015	2.129



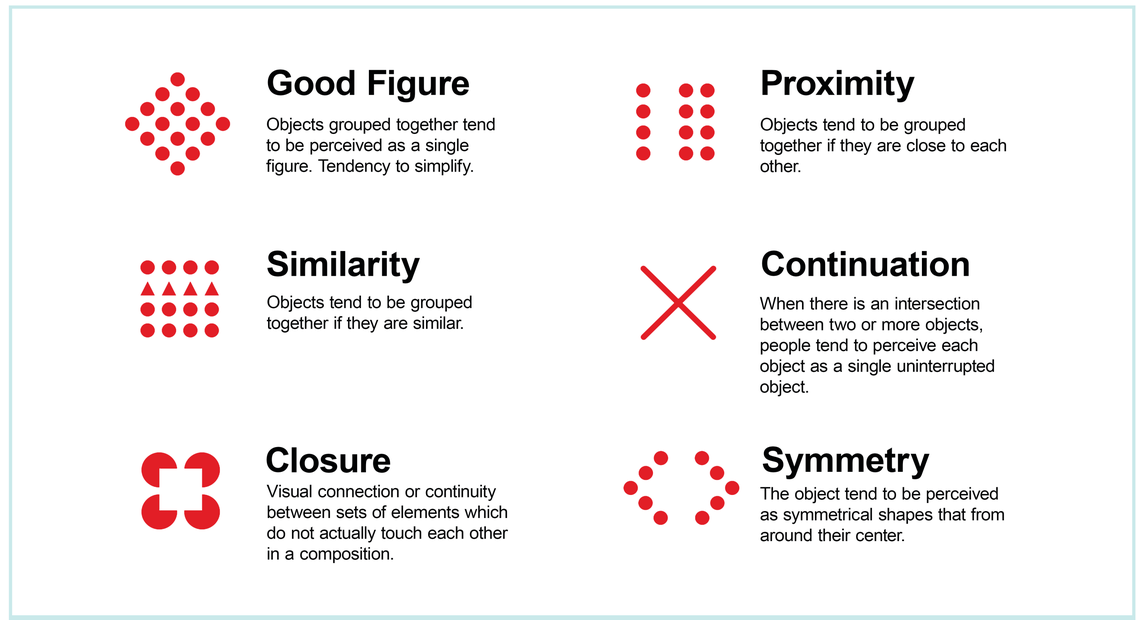
Example of data visualisation which accelerates the perception of information - preattentive processing. (Tetiana Donska, 2022, ”The Mind‘s Eye: A Look at Data Visualization Psychology ”)

Preattentive processing for rapid perception

A key finding from psychological studies is the discovery of a limited set of visual properties that are detected very rapidly and accurately by the low-level visual system. This system is called „preattentive“ (*Healey, 2007*), where the term itself is related to attention. Furthermore, Healey (*2007*) investigates four theories of preattentive processing, which are feature integration theory, texton theory, similarity theory, and guided search theory. While these high-level theories prove the existence of a more rapid perception and one that involves a longer search and processing time, Jacques Bertin (*1977*) introduced visual variables that trigger this pre-attentive response much earlier.

Retinal variables and gestalt theory

By learning what visual elements are automatically emphasized, we can design visualizations that tell the story of the data more effectively. Bertin’s (*1977*) set of retinal variables consisted of six key elements: position, size, value, texture, color (hue), orientations, and shape. There is a seventh retinal variable not listed by Bertin (*1977*), which is motion.



Examples of Gestalt theory prinsipals. (Retrieved from https://uxhints.com/visual-ui-design/)

In digital animated figures we can perceive differences in speed as an independent piece of information by comparison to the other six retinal variables. To facilitate possible insights into derived data, different visual characteristics can also be applied simultaneously, such as a chart effectively displaying temperature and agricultural population damage. Connecting the retinal variables of preattentive processing to psychological mechanisms of the human visual system draws a line to the influential human psychology theory of Gestalt (German: Gestaltlehre). Developed in the early twentieth century by German psychologists Max Wertheimer (1880–1943) and his colleagues Wolfgang Kohler (1887–1967) and Kurt Koffka (1886–1941). Where there is a more holistic paradigm and a psychotherapeutical part in this theory, following the dogma of „The whole is more than the sum of its parts“, we can derive the concept of some basic laws that govern our perception, which was stated by Wertheimer (*Köhler, 1969*). Gestalt theory explains the pattern-seeking natural to human behavior with scientific validation that can be used to create images that communicate information in a more effective way. The human visual system understands an image using proximity, similarity, continuity, symmetry, close and relative size features.

In summary, findings from studies of the last 30 years can deduce that common characteristics for data visualization focus on readability, recognizability, and meaning. The transformation of data to information facilitates these characteristics. Where the subconscious preattentive information processing of the human visual system can be used in favor of rapid cognition by respecting retinal variables in relation to the rules of gestalt theory.

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