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1 Hypothese

Die Differenzierbarkeit von Farben beim Betrachten von Choroplethenkarten hängt vorallem von der Farbdistanz zwischen den Farben und der Anzahl der Farbklassen ab.

2 Introduction

From a designer's perspective, colors play an essential role in cartography. Nevertheless, according to Brychtová and Çöltekin (2017), there is little research to empirically determine the minimum effective color distance to safely and correctly distinguish cartographic symbols.

The ability to distinguish colors and shades of the same color plays an important role in cartography (Brychtová & Çöltekin, 2017)

Lack of proper visual distance in variables colour hue and colour value is a known contributor to legibility problems in map use tasks (Chesneau, 2007; Steinrücken & Plümer, 2013; Stigmar, 2010)(Brychtová, 2015)

2.1 Choropleth maps

3 Basic color information

3.1 Human' color perception

Although our current understanding is that color vision results from the response of three photoreceptor cells in the retina to incident light, their perception cannot be fully understood. This may be due to both individual and environmental factors that influence color perception. (Lafer-Sousa et al. 2015; Xiao et al. 2016) (Gegenfurtner and Sharpe 2001). .

Some of these factors can be, for example, the amount of light in the environment, shadows, surrounding materials, and reflectivity. In addition, the viewer's prior knowledge and cognitive biases play a significant role in color perception. (Derefeldt et al. 2004; Foster 2011).

In addition, there is evidence that the number and distribution of photoreceptors in the eye influences what we see (Roy et al., 1991), and that our brain assumes a particular direction or light source e.g., Gegenfurtner et al. 2015; Lafer Sousa et al. 2015; Winkler et al. 2015.

Thus, it can be said that the color perception of an individual is not stable over space and time. The same is true not only for individuals but also for groups.

Nevertheless, there are many efforts to model and quantify color perception such as mathematical models that attempt to determine thresholds by which two colors or shades of the same color become distinguishable.

This color distance describes a metric that quantifies the human ability to visually distinguish differences between two colors see chapter 3.1 (Brychtová & Çötekin, 2017).

3.2 Color spaces

4 Criteria

4.1 Color distance

Visual Distance in cartography is understood as a Measurement of Differences between visual variables such as size, shape, orientation and others (Brychtová, 2015). Here we focus on the variable of color hue and color value. The human perceived difference between two colors or color shades can be described as the color Distance. In other words, certain change of the colour in the perceptually uniform space produces equal change in human perception of that colour (Slocum et al. 2008 (Brychtová & Çöltekin, 2017)).

To describe the distance of two colors scientistis have developed a method to describe the color distance. To express color quantitatively a colour space corresponding to the human perception is needed. Such color spaces are called perceptually uniform or linear. The use of such color spaces try to ensure results of color distance which are proportional to the human perception (CIE, 2012 (Brychtová, 2015)). Presently the CIEDE2000 model (δE_{00} , equation defined in Sharma, Wu, & Dalal, 2005 (Brychtová, 2015)) is regarded as the best coinciding color space with visual perception.

- RGB cause RGB represents how colors are created on most digital screens. - RGB values do not lead to a specific color if not related to an absolute color space - As a color space sRGB is selected, since sRGB color space is supported by most digital screens. Other color spaces such as Adobe RGB are not fully supported by most digital screens. When publishing a digital map creators should choose colors which can be displayed by most screens, therefore sRGB is the color space to choose.

4.1.1 Equation

- transforming sRGB Colors to CIE XYZ Colors. - What are CIE XYZ Colors - For the transformation the sRGB values have to be in the range 0.0 - 1.0, therefore the most values have to be divided by 255 to normalize them.

4.2 Number of classes

4.3 Further aspects

4.3.1 Spatial distance

4.3.2 Brightness of colors

5 Examples

Brewer and her colleagues (Brewer et al. 2003; Brewer 1986, 1992, 1994, 1996, 1997, 1999; Harrower and Brewer 2003) did research on color, developing color schemes to visualize both quantitative and qualitative data. In the process, the online software ColorBrewer 2.0 was developed, which can be very helpful for many applications.

They used Munsell diagrams to design color schemes that would maintain consistency in perceived color distances between classes (Brychtová & Çöltekin, 2017).

The Munsell Color System is a color system that is the first complete, most widely used, and still in use today. It is based on three essential criteria: Hue, Chroma and Value, with Hue being

the most important criterion. Munsell chose five main hues: red (R), yellow (Y), green (G), blue (B) and purple (P). Now he subdivides the perceptible color nuances into further color tones, which are to represent the intermediate color tones: YR (yellow-red), GY (green-yellow), BG (blue-green), PB (purple-blue) and RP (red-purple). These ten hues are further subdivided a few times into ten gradations. Numbers from 0 to 10 are also added to the hues. Towards the outside, the saturation of the color (chroma) increases. The vertical center axis, which ranges from white (value 10) to black (value 0), which can be represented with colorants, is represented by the value. This results in a 10-row gray scale.

6 Conclusion

(Brychtová, 2015) (Brychtová & Çöltekin, 2017) (Sharma et al., 2005) (Brychtova & Coltekin, 2015) (Brychtová & Çötekin, 2017)