Perceiving Dark Mode Colour Schemes in Choropleth Maps

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Abstract:

Introduction

Dark mode is a design option that uses a dark background with light-coloured text and graphic elements. It is becoming increasingly popular in various applications - also in the cartographic field, as *Google Maps, Apple Maps* or various web mapping libraries support this option.

The advantages of dark mode are manifold - but also controversial and in some cases not yet verified. On the one hand, dark mode reduces the amount of blue light emitted by screens, thereby reducing eye strain. With OLED screens in particular, dark mode can extend battery life as the pixels emit their own light and only consume power when displaying bright colours. Finally, many people prefer the aesthetics of the dark mode.

Focus and Goal

Although dark mode is already integrated in many applications and some media generate maps simultaneously for print, desktop and mobile use, but also in light and dark mode by default, there is still a lack of in-depth knowledge regarding the perception of map colours in dark mode.

This article will focus on the design of choropleth maps. In particular, it is unclear whether the "light-is-more" order propagated by some application providers for the sequence of colours in relation to attribute values (compared to the concept of "dark-is-more" for light backgrounds) is actually intuitively understood by users.

Creating colour schemes for dark mode

General recommendations for the use of colours in dark mode include, for example, maintaining the best possible contrast to the dark background - according to the Web Content Accessibility Guidelines (WCAG), this should be at least 4.5:1 for normal text (although this value can be reduced for larger text or even for area fillings such as in choropleth maps). In addition, a pure black background and pure white text or graphics should be avoided. Finally, colours that are too saturated should be avoided.

Three dark mode variants are implemented and tested for the following study (Fig. 1):

1. *Original*: The light-mode colour scheme - taken from the *Color Brewer* - is adopted unchanged.
2. *Datawrapper*: The dark mode scheme proposed by the online tool *Datawrapper* (datawrapper.de) is calculated from the given light mode scheme using the complementary lightness, transferring the original contrast of the lightest colour to the light background to the darkest colour with regard to the dark background, and applying a gamma correction. A very dark grey (#121212) is used as background.
3. *Own*: A separate single hue colour scheme is created that fulfils the following conditions: Use of a constant hue and a medium saturation, definition of the darkest colour (minimum contrast of >2:1 against background #121212) and the brightest colour (approx. 90 %) as well as a linear interpolation of the lightness for the intermediate colours, also considering colour distances $\Delta E_{00} > 10$. For multi-hue colour schemes, the hue is varied accordingly.
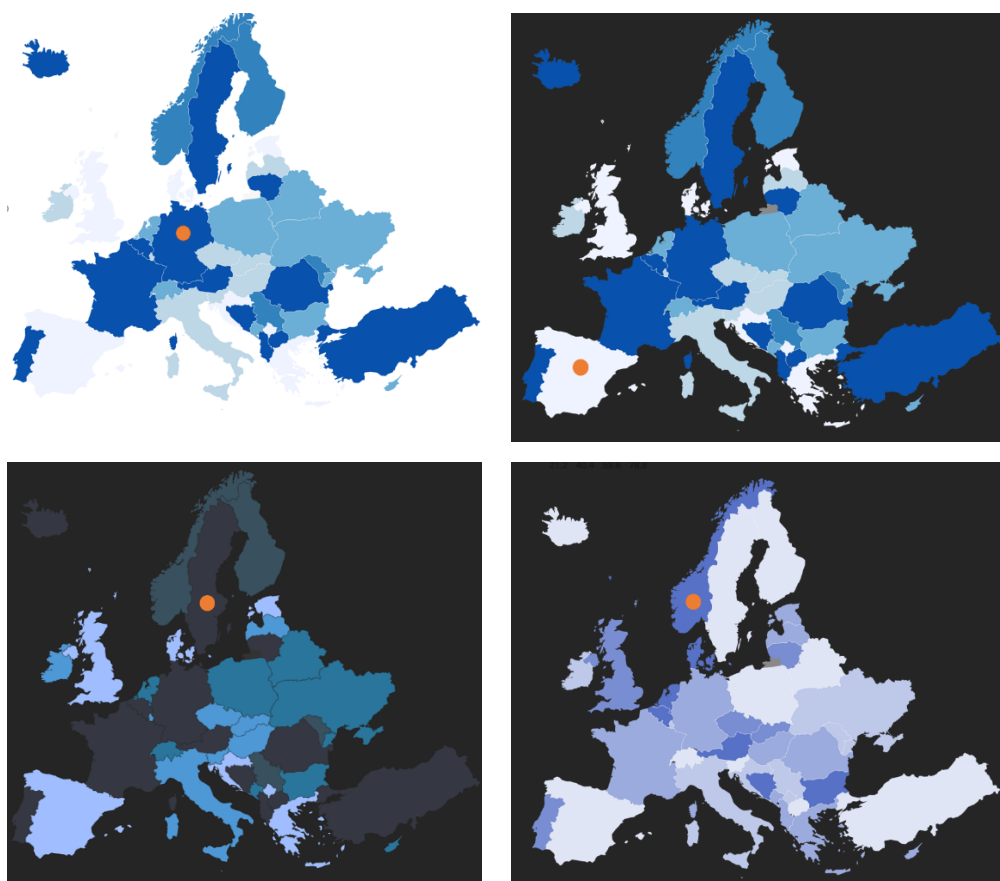
Figure 1. Maps examples for light mode (top left), dark mode using Original scheme (top right), Datawrapper scheme (bottom left) and Own scheme (bottom right).

Empirical Study

An empirical quantitative study will investigate the following hypotheses:

(H1) The perception of sequential colours in dark mode follows the light-is-more concept - based on experiences of providers and the idea that the highest contrast to the background creates the strongest impression.

(H2) This perception is not as clear as the dark-is-more concept in light mode, especially among Cartography experts who have consciously used dark mode so far.

(H3) There are significant differences between different versions of the dark mode colour schemes.

In addition to the expertise and possible colour vision deficiencies of the users, the independent variables of the study are the various dark mode colour schemes - applied to two sequential schemes (blue, red) and one multi-hue scheme (yellow to red). Randomly generated data sets with different base maps are produced in order to avoid any associations with real topics. Examples are also presented in light mode for referencing purposes.

The perception of the colour sequence (light-is-more vs. dark-is more) is registered as a dependent variable. For this purpose, one region per map is marked with a circle (fig. 1) - the test subjects are then asked to decide whether this colour belongs to the class with the largest or smallest values (or whether an assignment is difficult).

Finally, the three variants of the dark mode schemes for the three examples (blue, red, yellow-red) are juxtaposed and the question of aesthetic preference is posed.

The preliminary study for this project has been completed and the web-based survey is currently underway, the results of which will be presented at the conference and will serve as a basis for further work in connection with the design of (thematic) maps in dark mode.