Color in cartography:
On successful color use in visualization

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The 7th ISDE International Lectures

Evaluation of Cartographic Presentation Methods

J. Korycka-Skorupa

I. Karsznia

T. Nowacki

T. Panecki

K. Słomska-Przech

W. Pokojski

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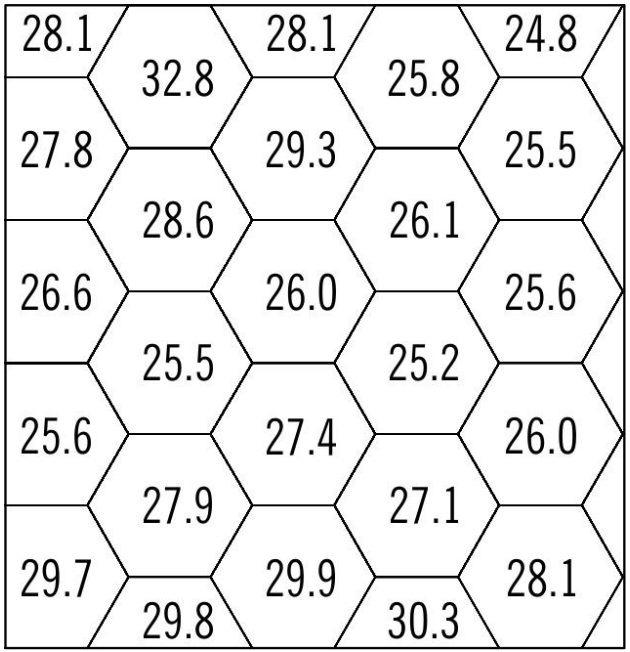
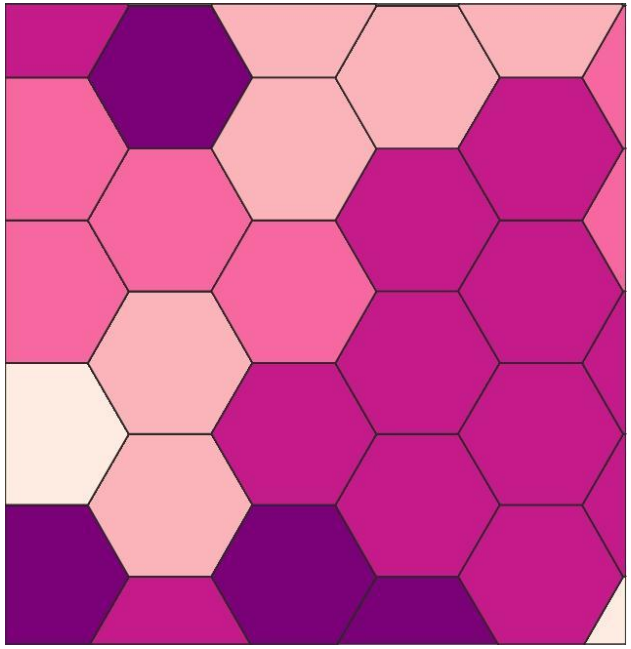
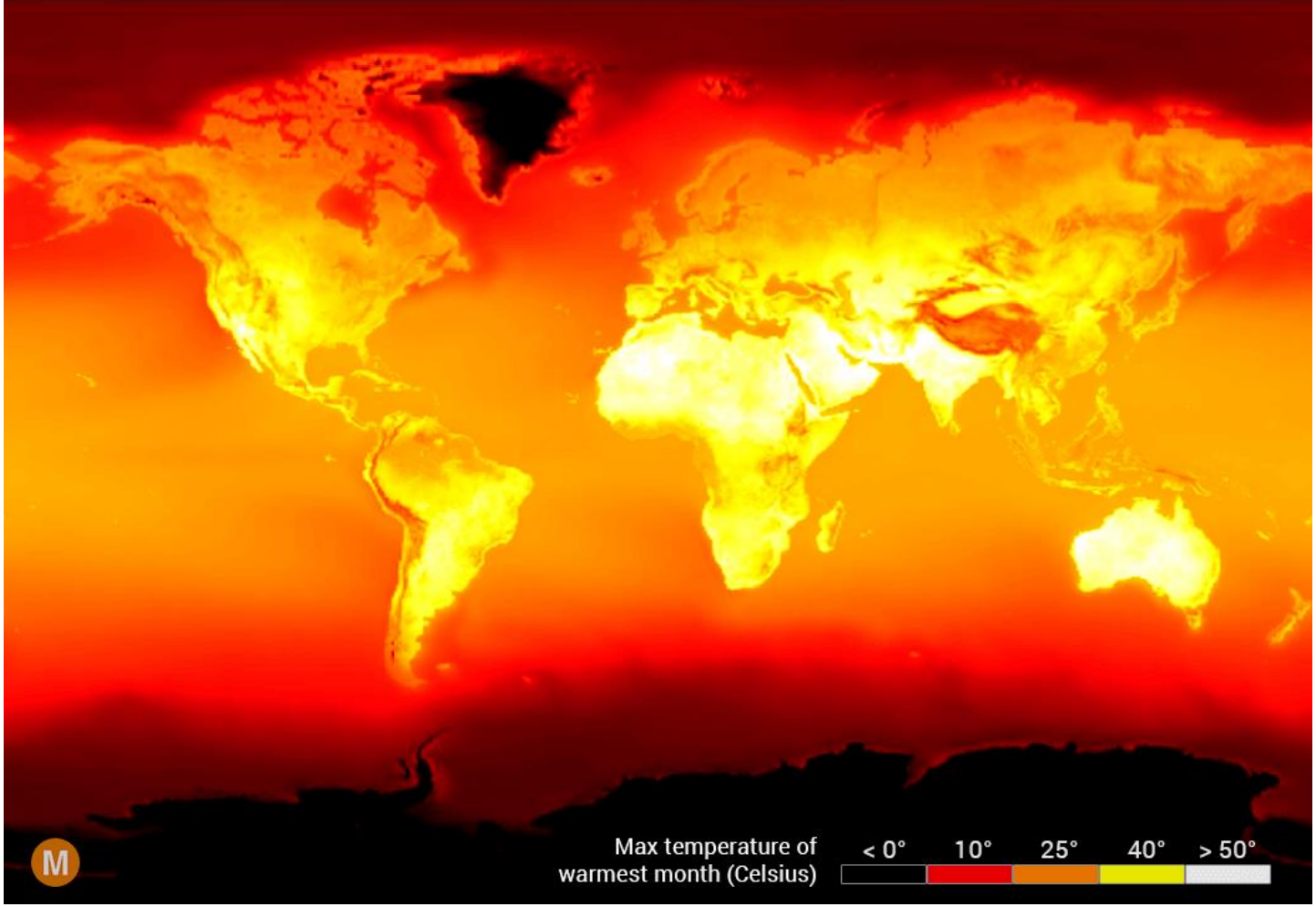
A. Çöltekin

Color not only beautiful

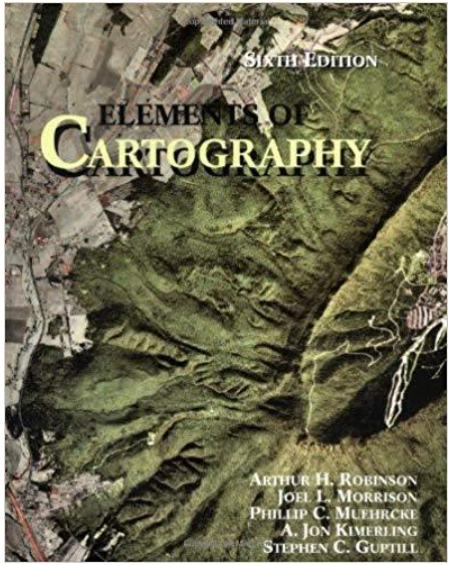






Source: M. Galka, https://metrocosm.com/peak-temperature-map/

They know…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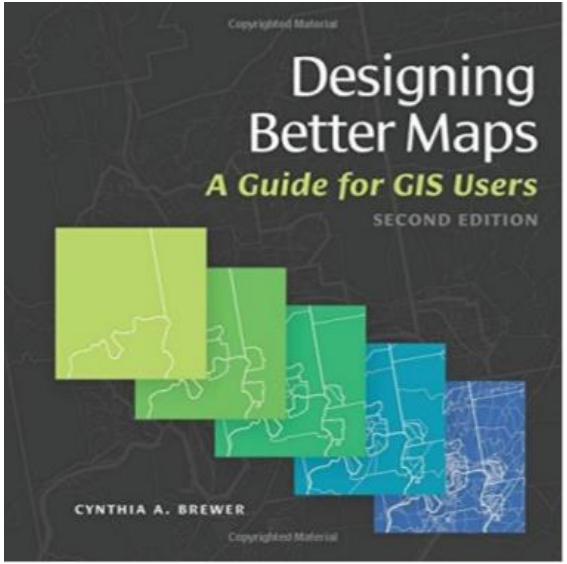
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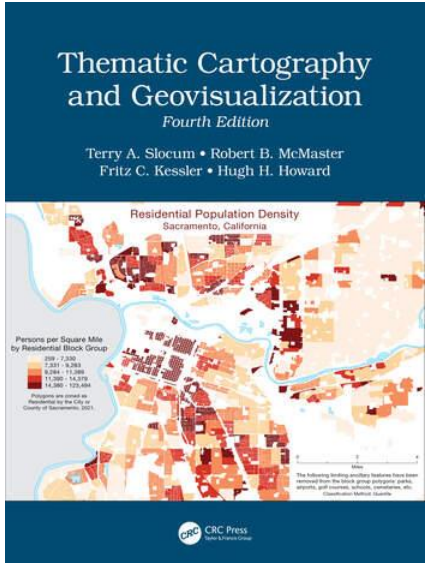
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Fourth Edition
Terry A. Slocum • Robert B. McMaster
Fritz C. Kessler • Hugh H. Howard
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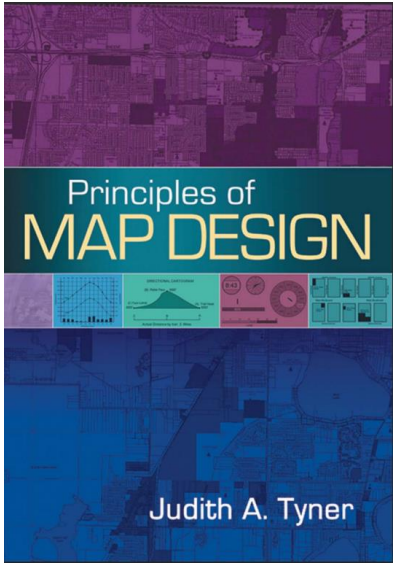
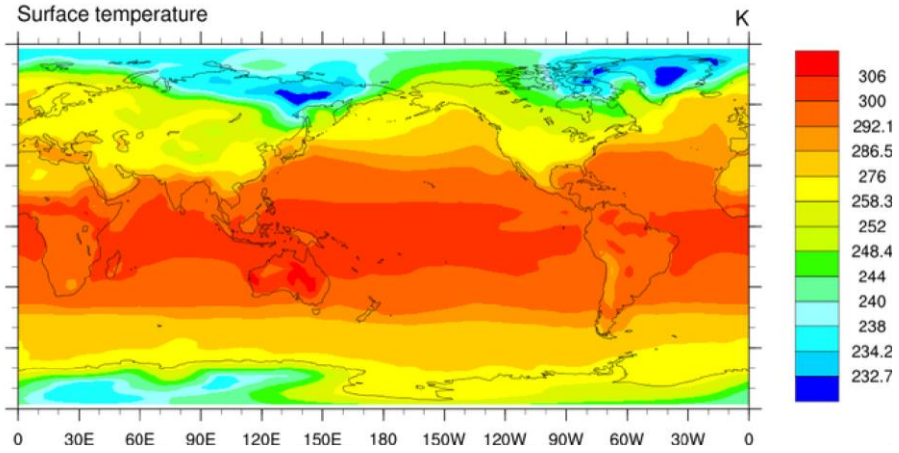
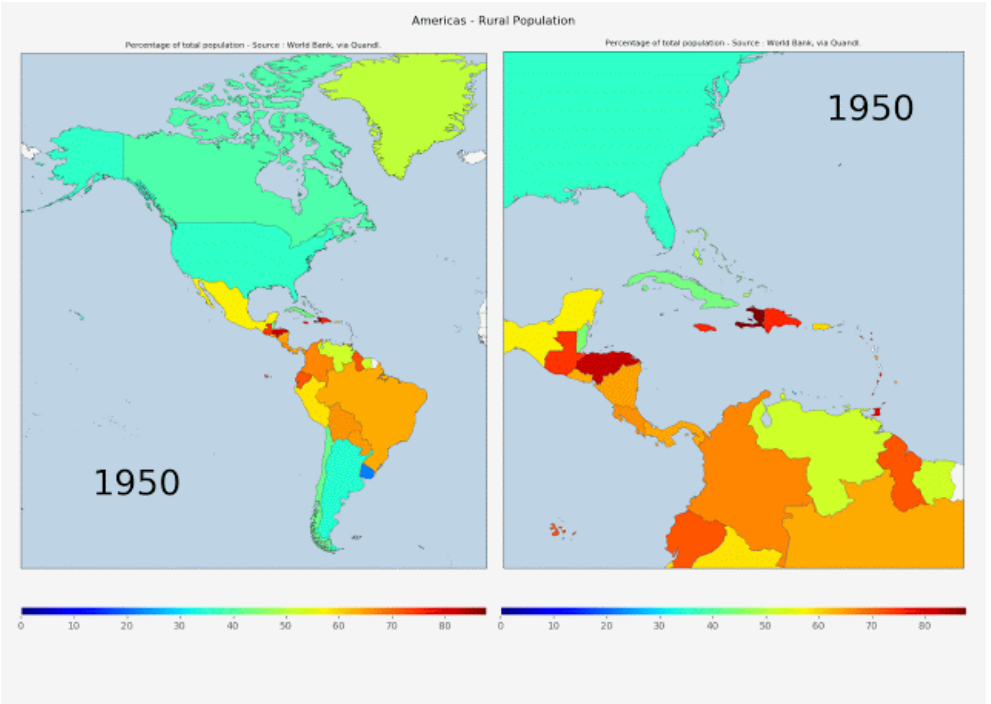
Sacramento, California
Persons per Square Mile by Residential Block Group
CRC Press


Principles of
MAP DESIGN
Judith A. Tyner

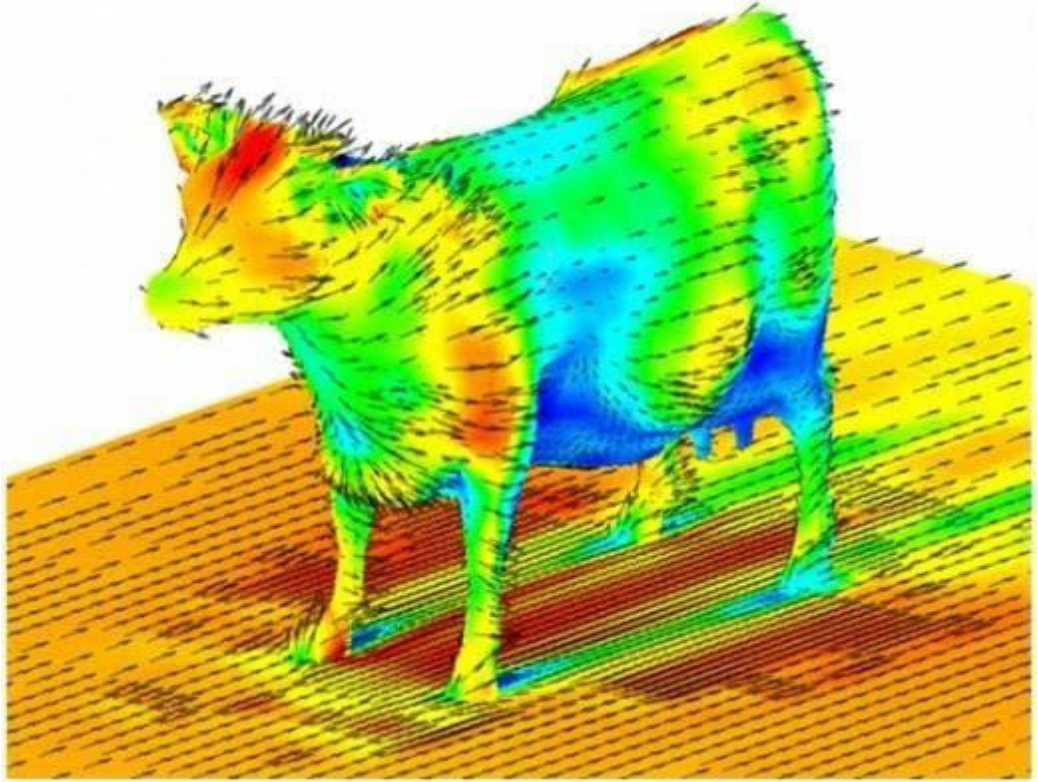
They know…?





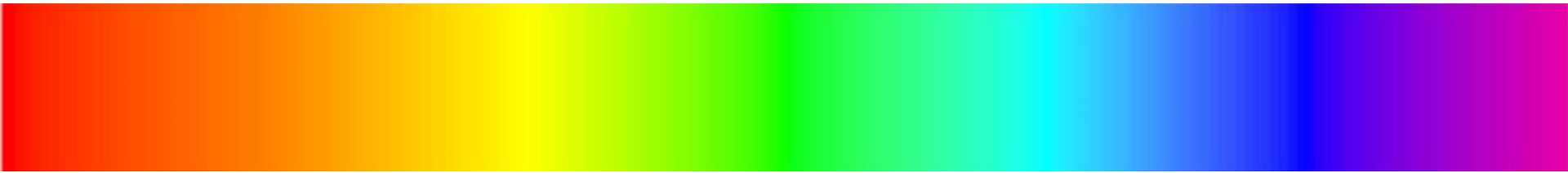
Source: https://www.ncl.ucar.edu/Applications/color.shtml
https://datasoaring.blogspot.com/2018/12/americas-rural-population.html

They know…?



Source: https://oppositelock.kinja.com/the-aerodynamic-efficiency-of-a-cow-1728510063

Rainbow color scheme

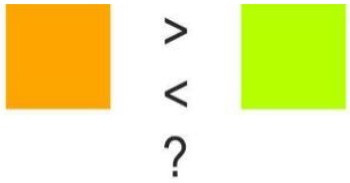


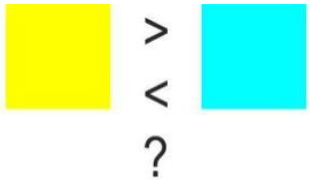
‘Good color scheme’ standards by Levkowitz and Herman (1992)

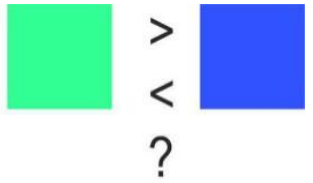
Ability to present:

- order
- uniformity
- representative distance
- do not create false boundaries

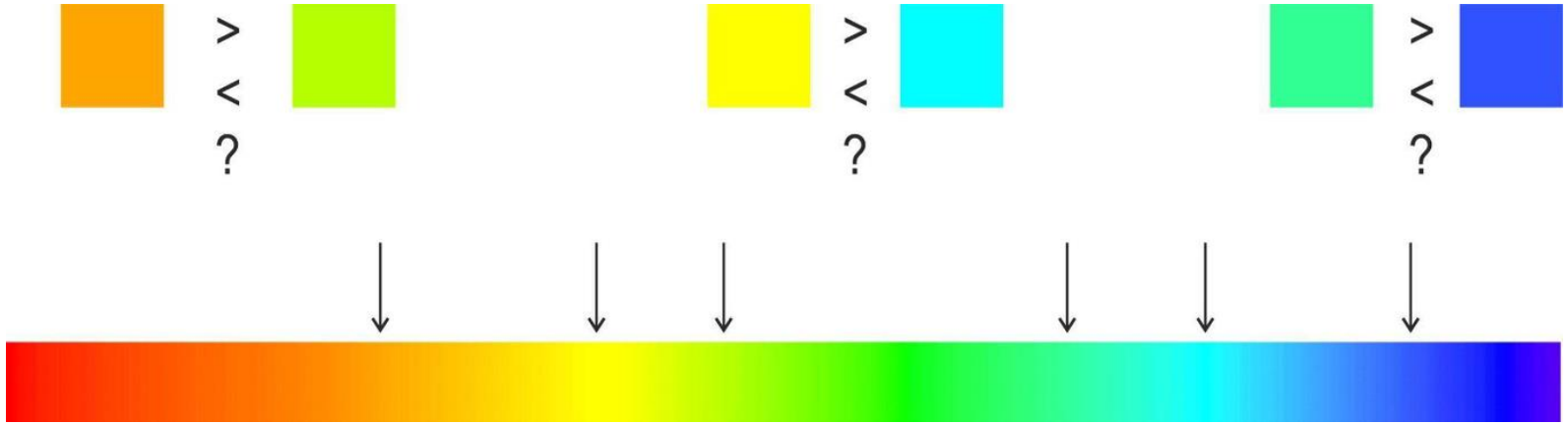
Order



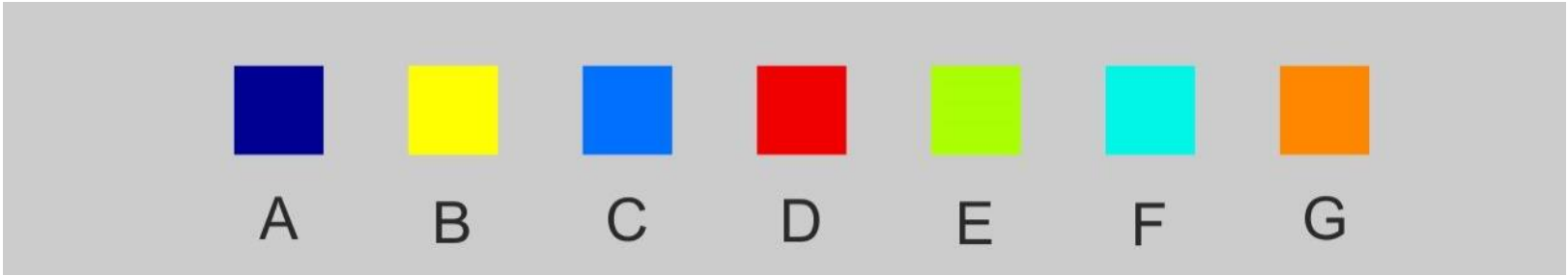




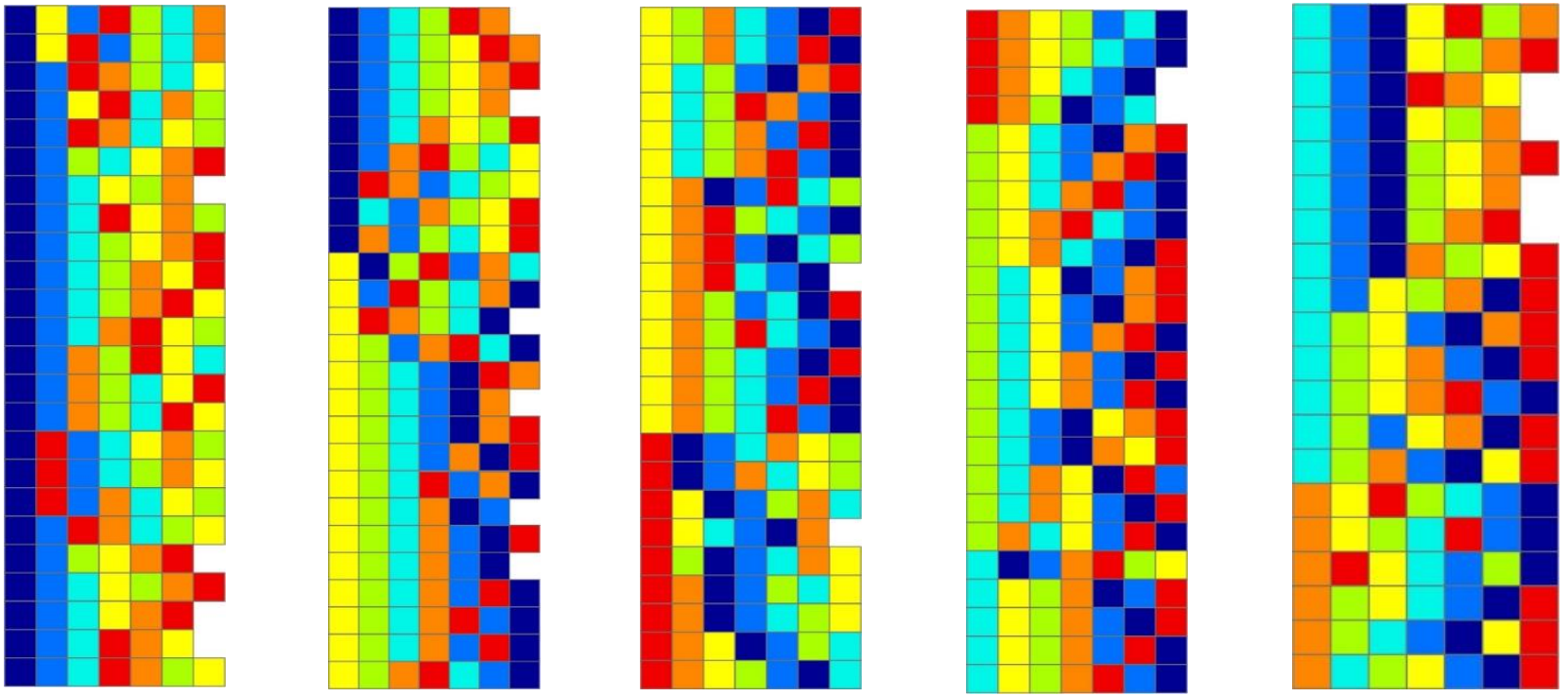
~~Order~~



Order



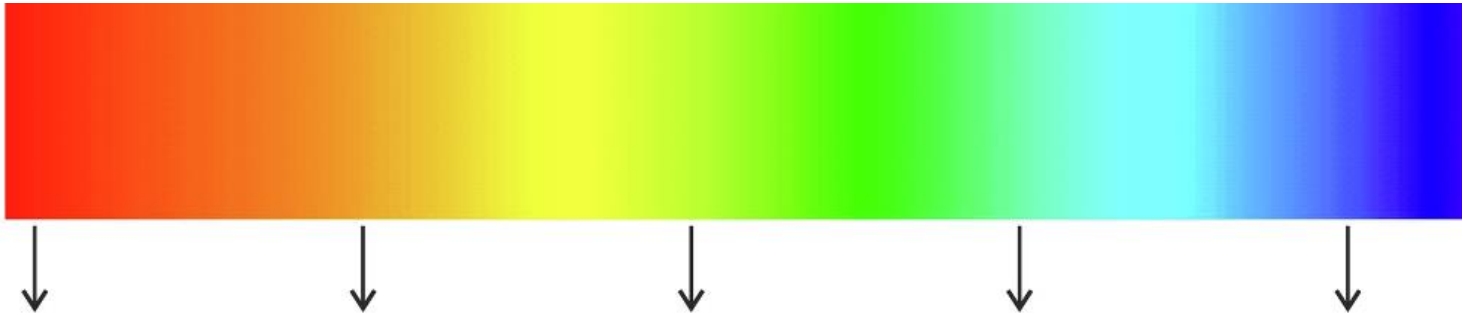
~~Order~~



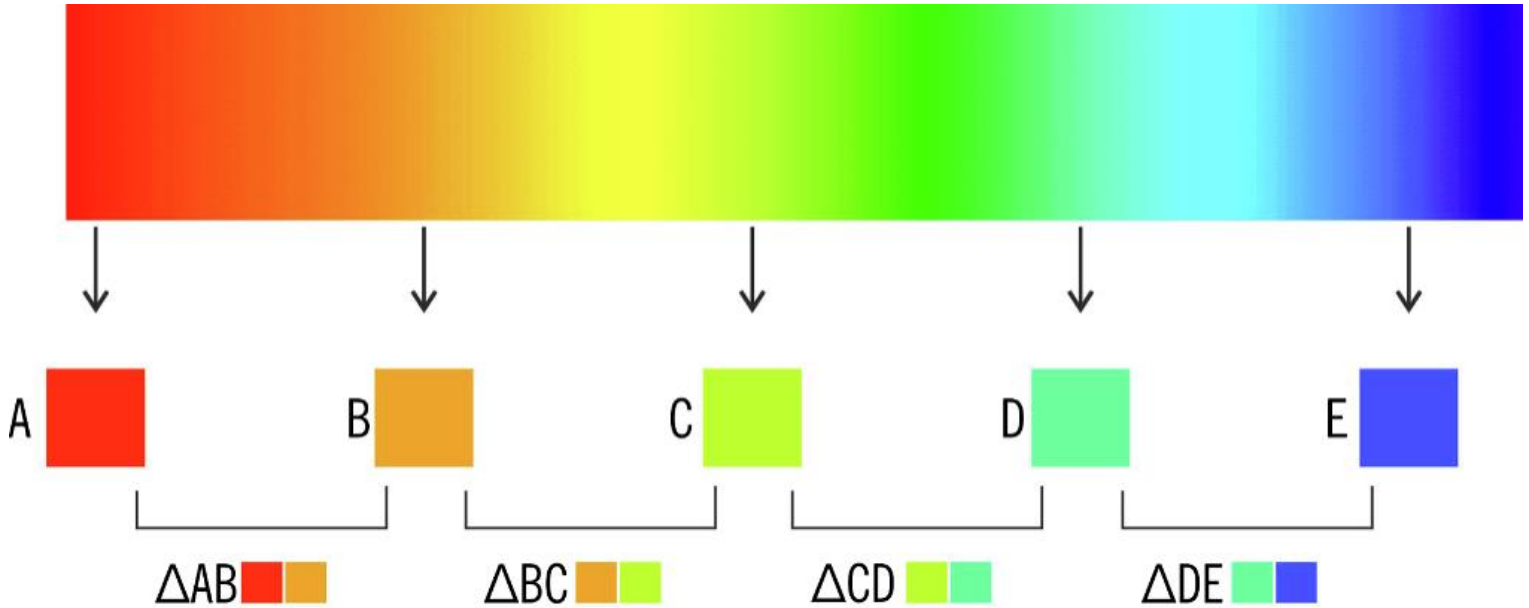
122 different sequences

Gołębiowska I.M., Çöltekin A. 2022. “Rainbow Dash: Intuitiveness, Interpretability and Memorability of the Rainbow Color Scheme in Visualization.” IEEE Transactions on Visualization and Computer Graphics 28 (7): 2722–33.

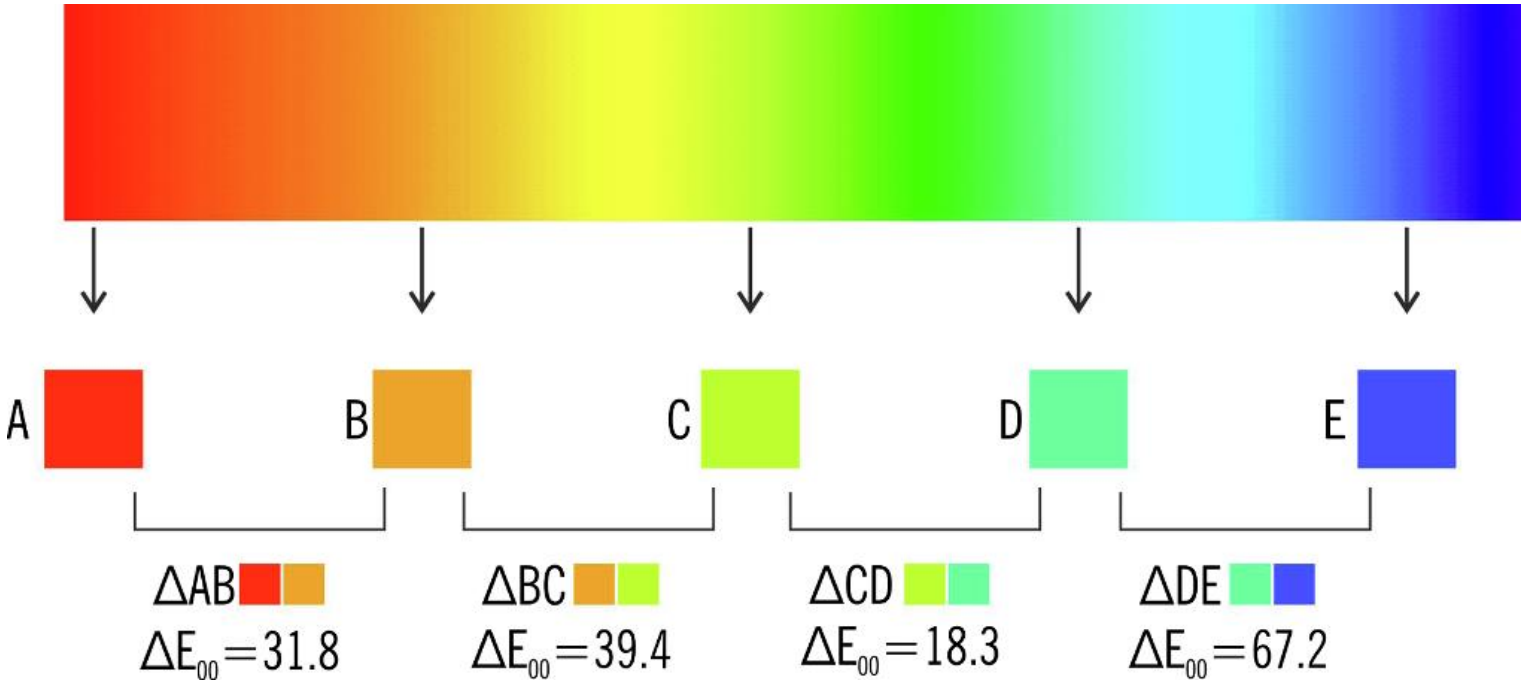
Uniformity



Uniformity

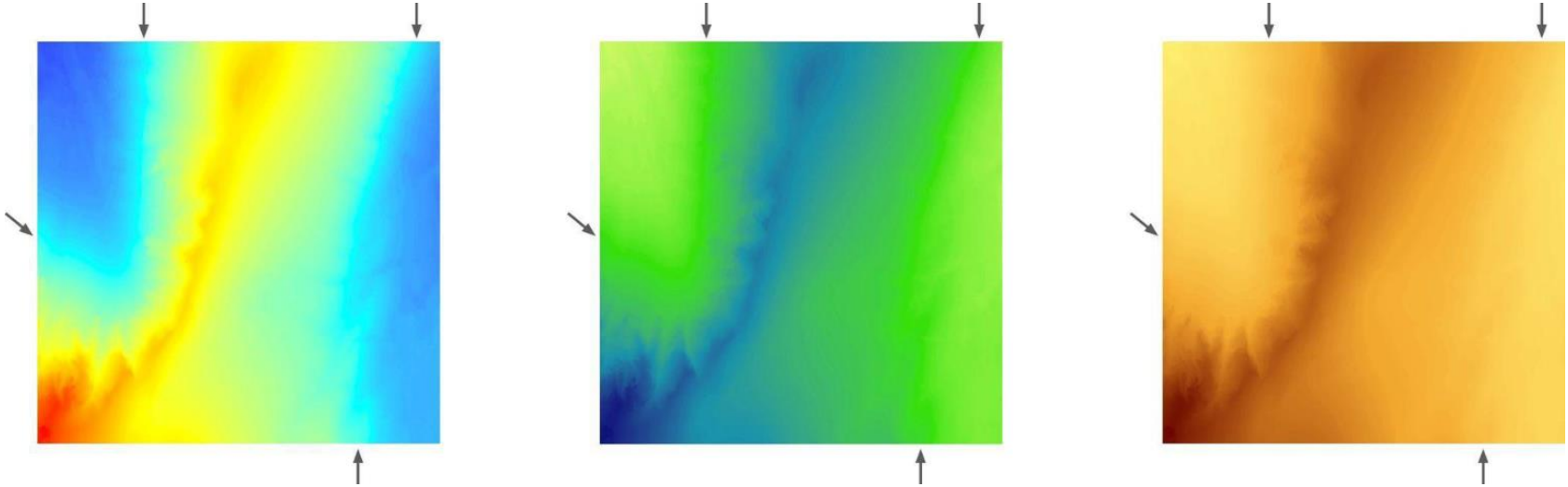


~~Uniformity~~

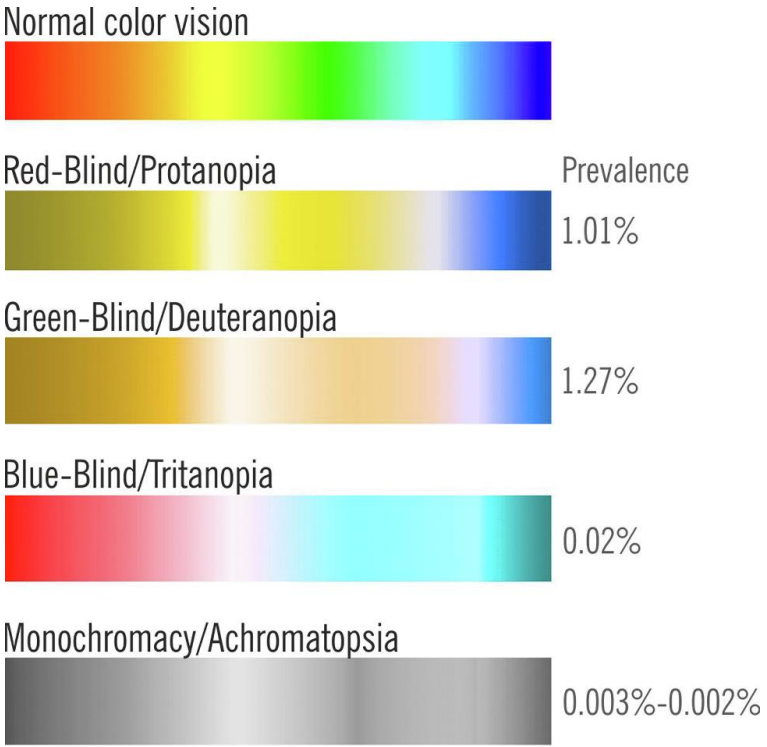


Sharma G., Wu W., Dalal E.N. 2005. “The CIEDE2000 Color-Difference Formula: Implementation Notes, Supplementary Test Data, and Mathematical Observations.” Color Research & Application 30 (1): 21–30.

~~do not create false boundaries~~



~~facilitate vision for all~~

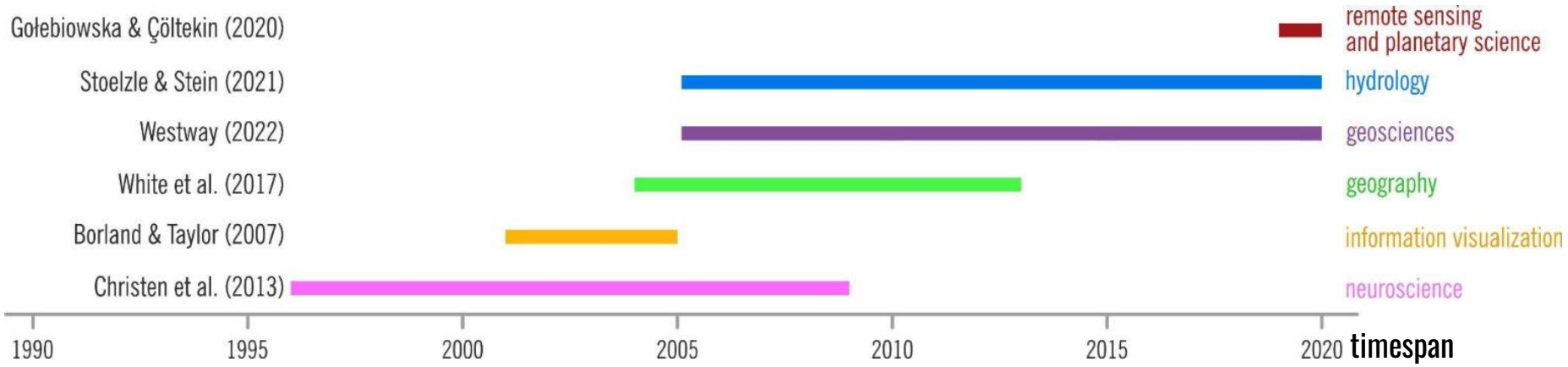


Rainbow evaluated

- prevalence in scientific journals

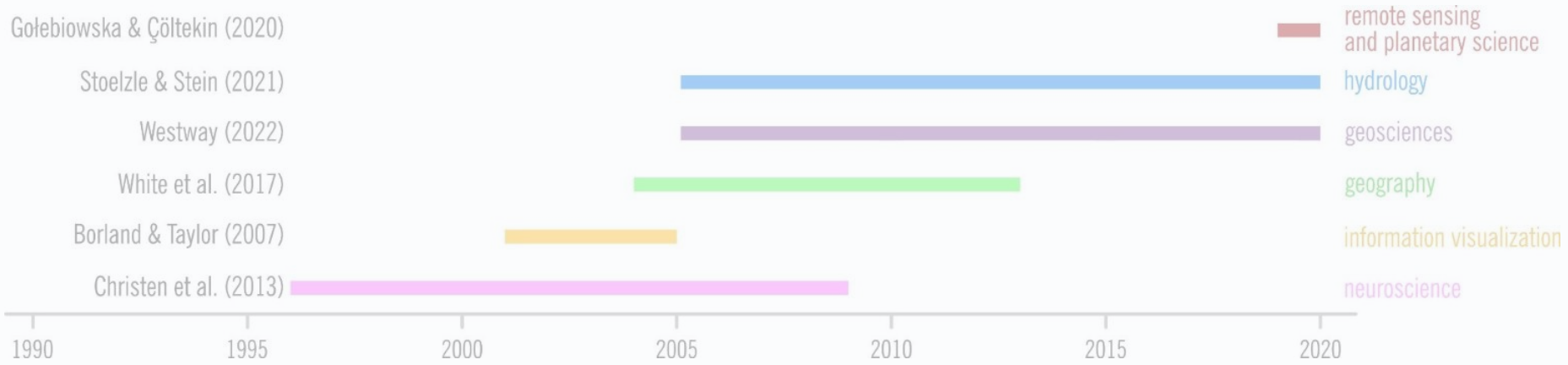
- empirical user studies

Various disciplines covered



Different conditions of analysis…

- timespan:

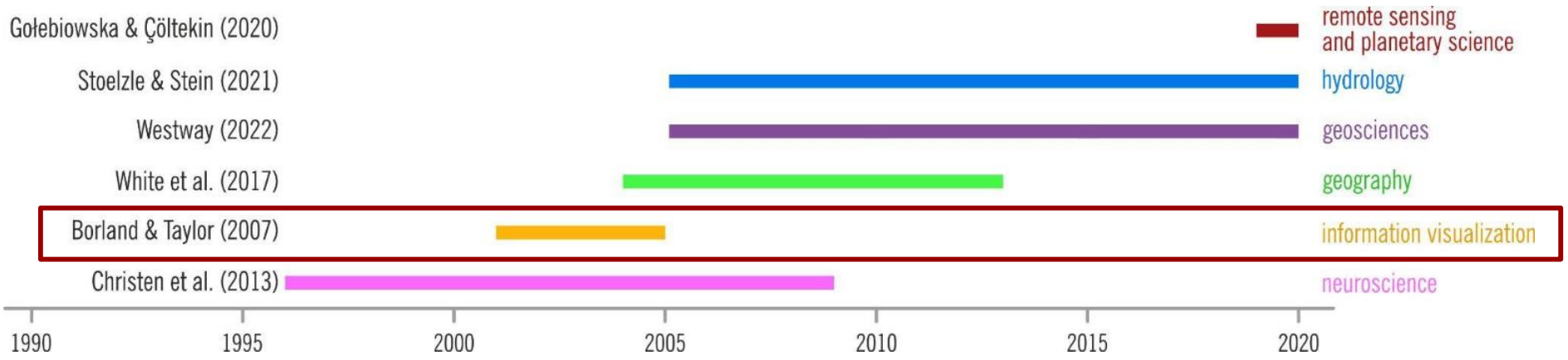


- sample size: from 180 till almost 4K papers
- metrics: % of images; % of images using quantitative data visualizations, % of published papers, % of papers using pseudocoloring…

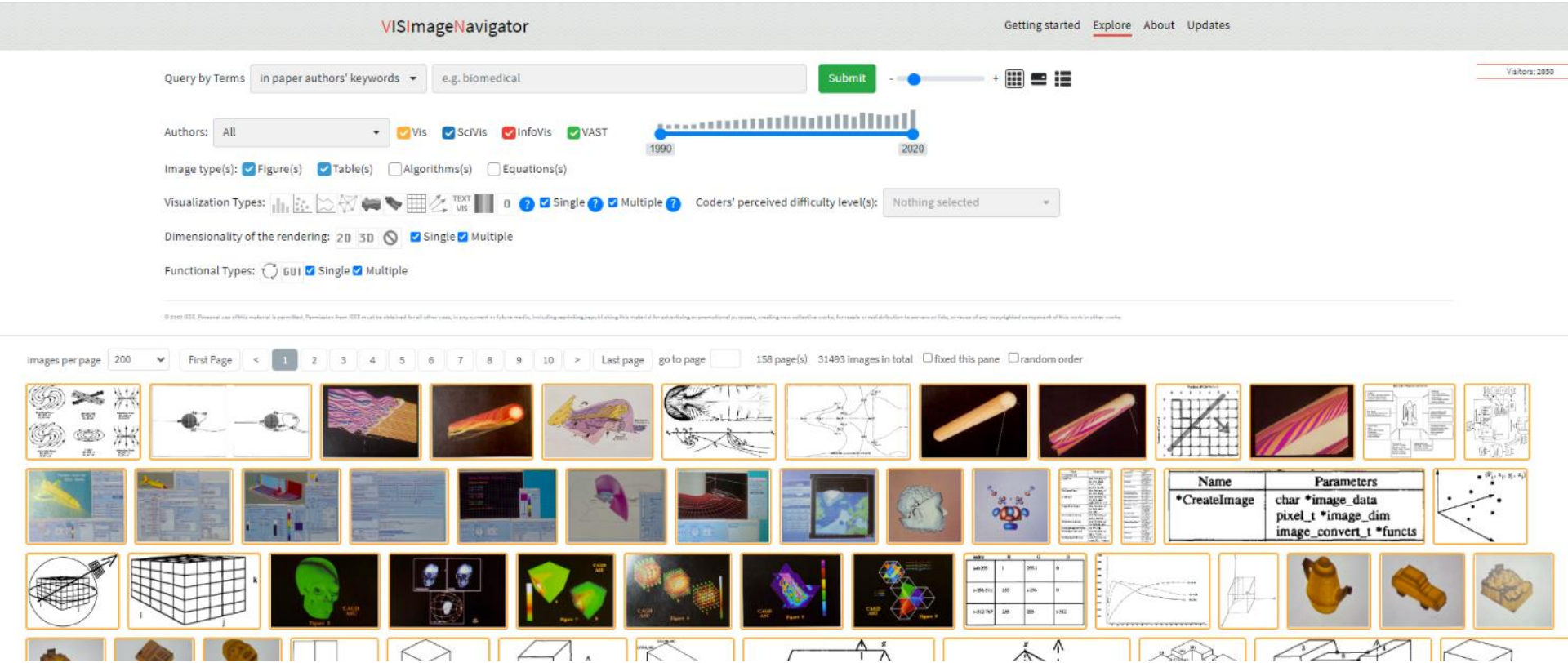
…but similar conclusions

…but similar conclusions

Rainbow (still)...?



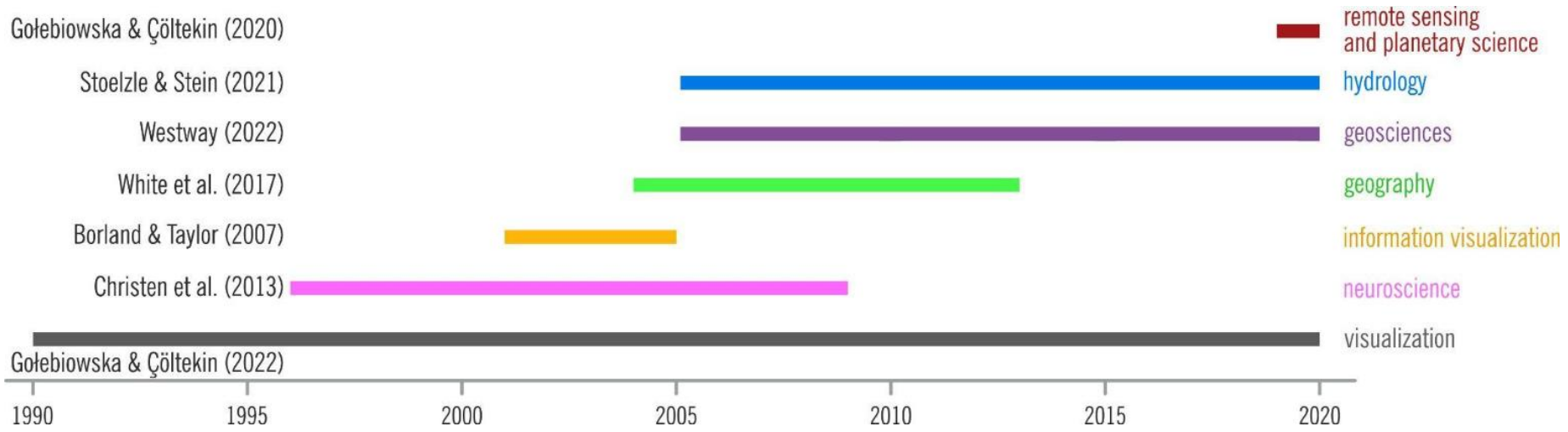
Replicating the RC prevalence in information visualization

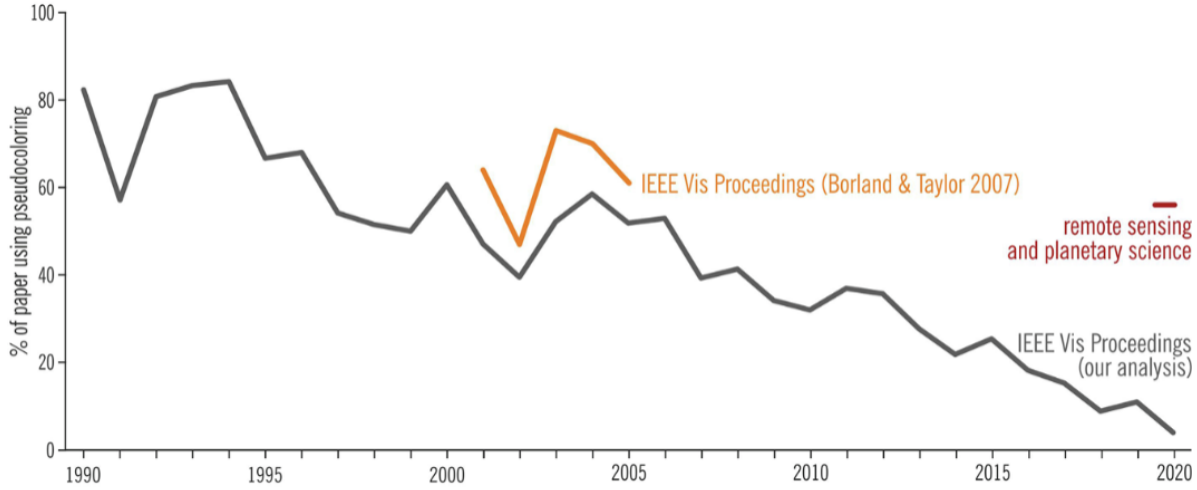


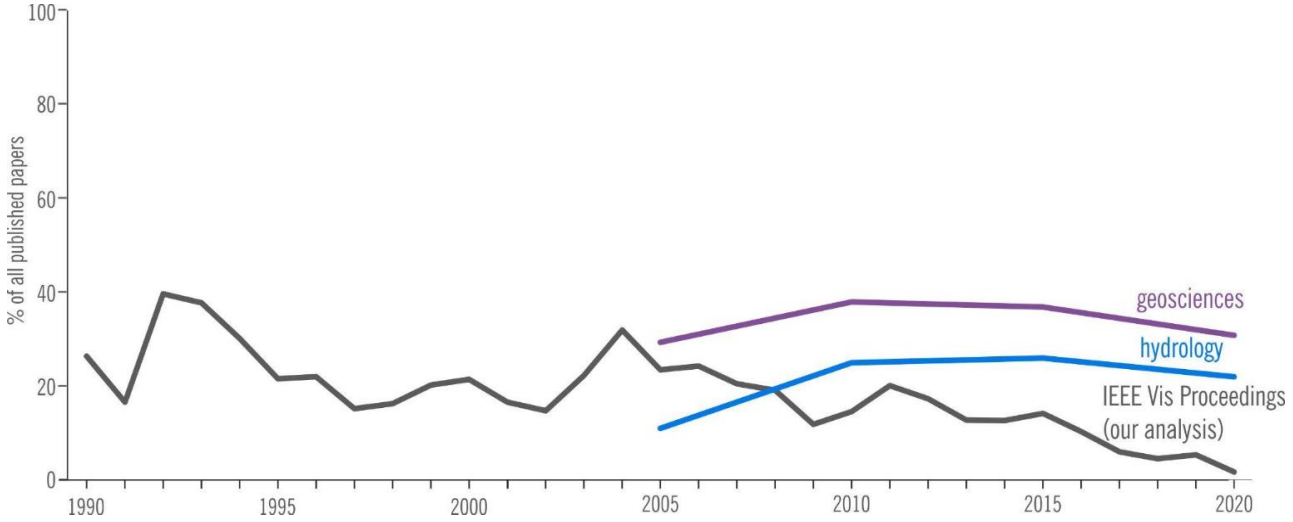
Chen, J. et al. 2021. “VIS30K: A Collection of Figures and Tables From IEEE Visualization Conference Publications” IEEE Trans. Visual Comput. Graphics 27 (9), 3826–3833

Our analysis covered

28,354 images from 3,057 papers




% of paper using pseudocoloring
100
80
60
40
20
0
1990
1995
2000
2005
2010
2015
2020
IEEE Vis Proceedings (Borland & Taylor 2007)
remote sensing
and planetary science
IEEE Vis Proceedings
(our analysis)


% of all published papers
100
80
60
40
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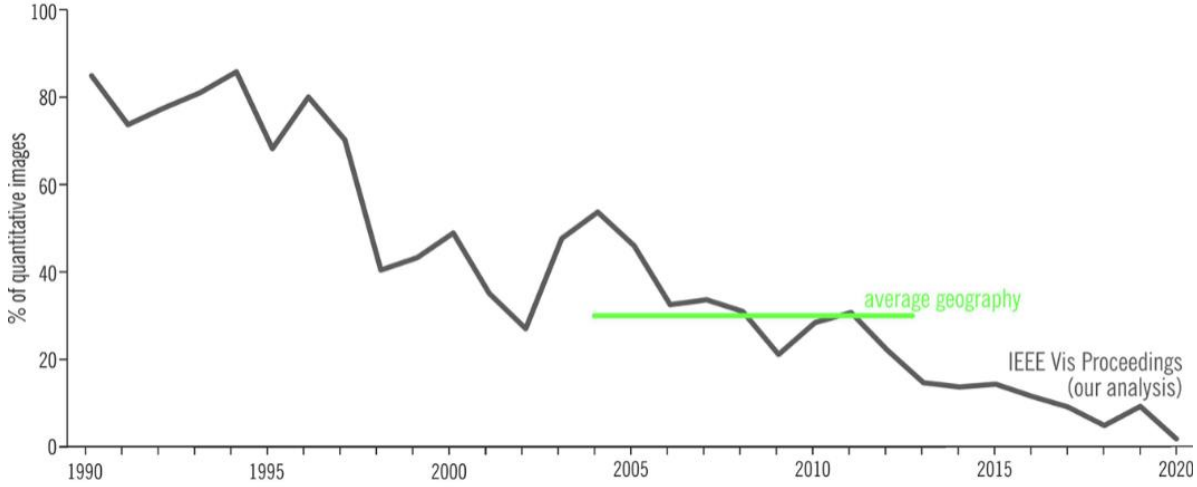
1990
1995
2000
2005
2010
2015
2020
geosciences
hydrology
IEEE Vis Proceedings
(our analysis)


100
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% of quantitative images
average geography
IEEE Vis Proceedings
(our analysis)
1990
1995
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2005
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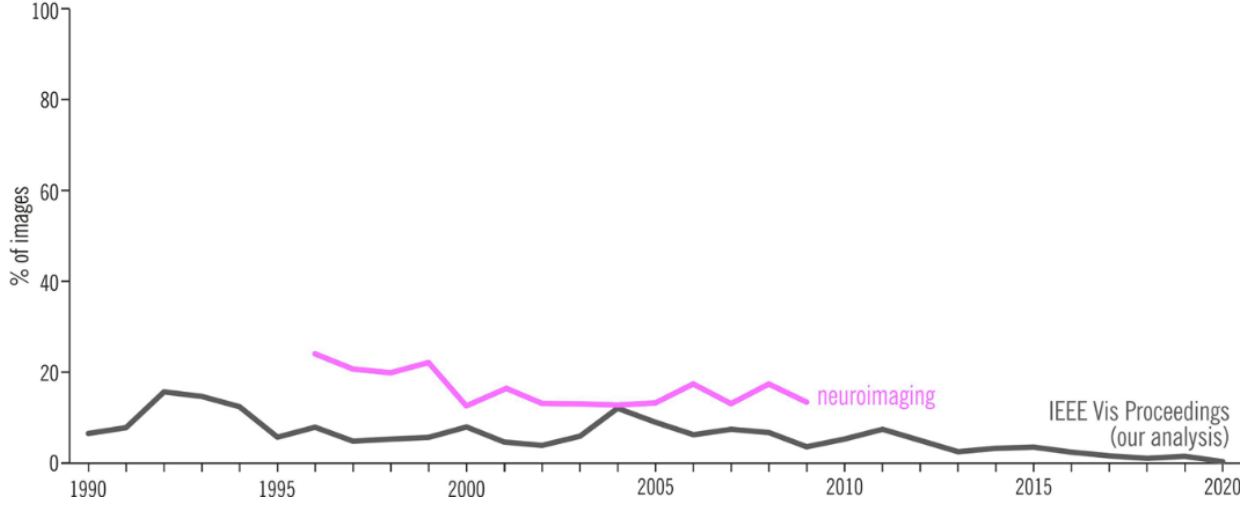
2015
2020

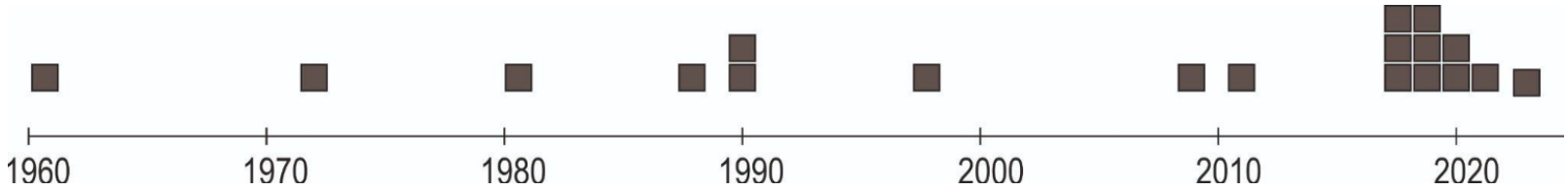

100
80
60
40
20
0
% of images
neuroimaging
IEEE Vis Proceedings
(our analysis)
1990
1995
2000
2005
2010
2015
2020

Rainbow evaluated

- prevalence in scientific journals
- 23 empirical user studies

Reda (2022)
Christen et al. (2021)
Reda & Szafir (2020)
Golebiowska & Coltekin (2020)
Dasgputa et al. (2020)
Karim et al. (2019)
Quinan et al. (2019)
Ware et al. (2019)
Liu & Heer (2018)
Reda et al. (2018)
Reda & Papka (2018)
Szafir et al. (2016)
Samsel et al. (2015)
Borkin et al. (2011)
Hyslop (2007)
Rogowitz & Kalvin (2001)
Brewer et al. (1997)
Kumler & Groop (1990)
Mersy (1990)
Ware (1988)
Olson (1981)
Cuff (1972)
McCarthy & Salisbury (1961)

Rainbow evaluated for a long time

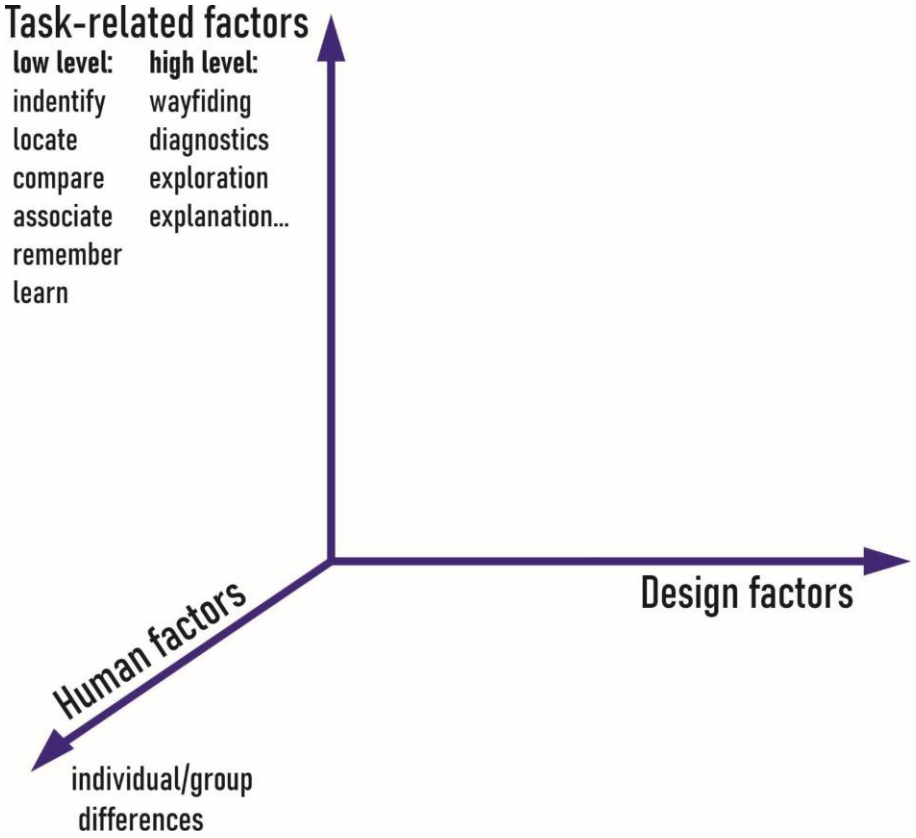


Different conditions of studies…

- visualization types
- color schemes compared to RC
- measured metrics
- participants: number, background

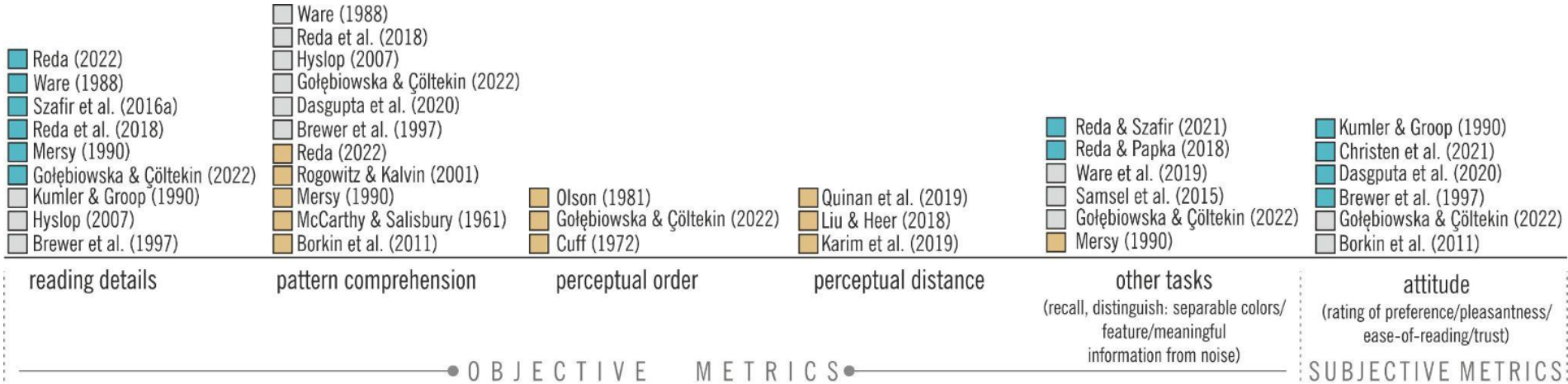
… and mixed outcomes

Factors to consider



Çöltekin, A. 2019. “What Contributes to the Complexity of Visuospatial Displays?” In Abstraction, Scale and Perception. International Cartographic Association Joint Commission Workshop, 1–2.

Task type matters



Result of a study

- rainbow better than other tested color schemes
- mixed or neutral
- rainbow worse than other tested color schemes

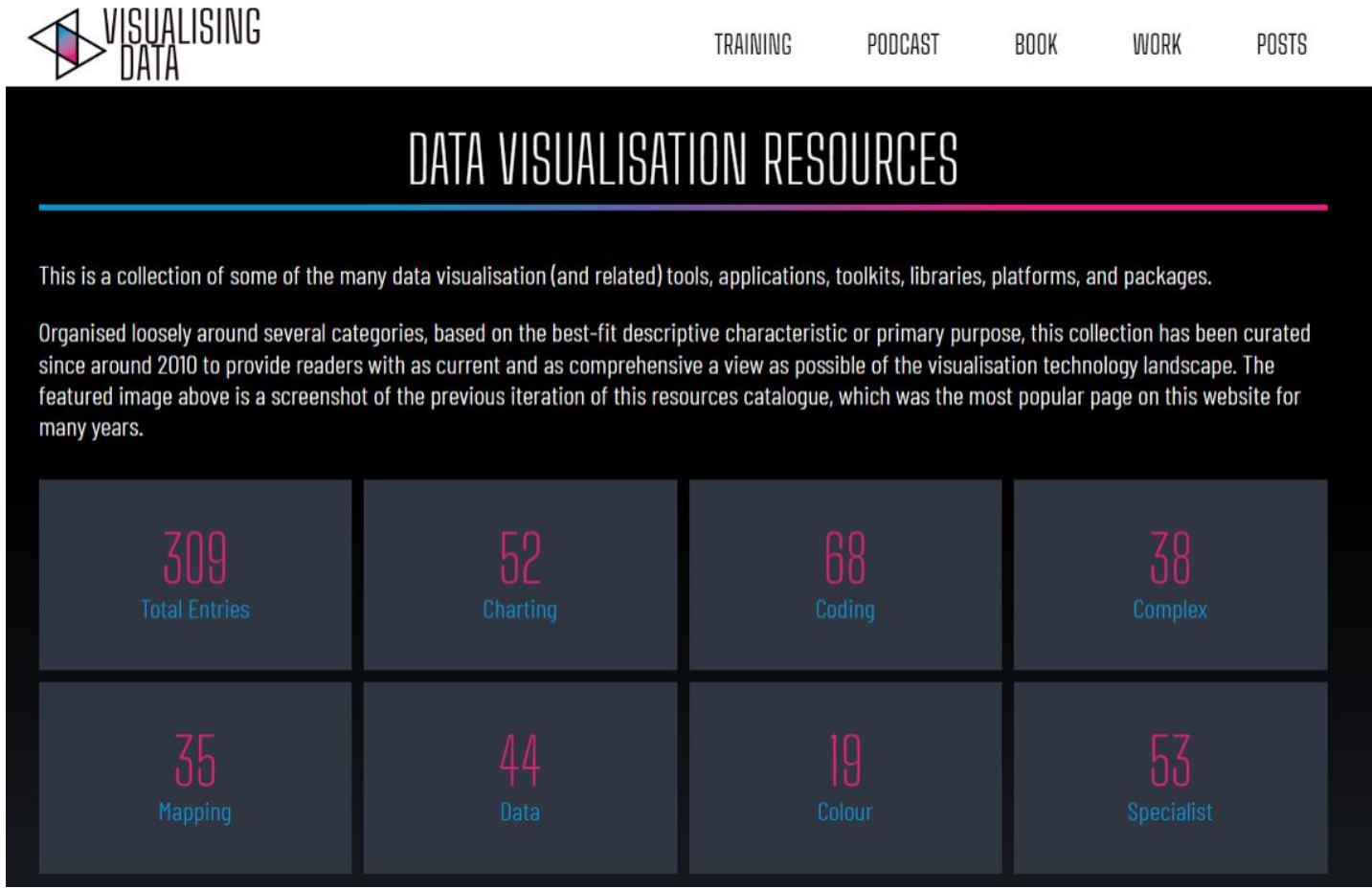
Conclusions

- visualization community gradually moved away from using the RC, in other sciences the RC is still prevalent;
- the RC supports retrieving values -> the hues are highly discriminable,
- RC is not great for understanding patterns -> it generates false boundaries and distorts distances,
- RC is definitely not a good fit to show order in values
- if one must opt for the RC, a legend is an essential element to support users.

Take away

- make informed color design choices based on theory of colors and empirical evidence
- not every eye-grabbing color scheme is a correct choice
- not every popular color design is correct one
- not every default setting in software is the correct one
- make use of online support

Online support



SCAN ME

Source: https://www.visualisingdata.com/resources/ Andy Kirk

COLOUR

This is a collection of tools for generating and editing colour palettes, as well as practical, theoretical, and inspirational sources of guidance.

SPECIALIST

This is a collection of design, presentation, publishing and niche resources that enhance the visualisation development workflow.

More details

Rainbow Dash: Intuitiveness, interpretability and memorability of the rainbow color scheme in visualization

Izabela M. Gołębiowska, Arzu Çöltekin

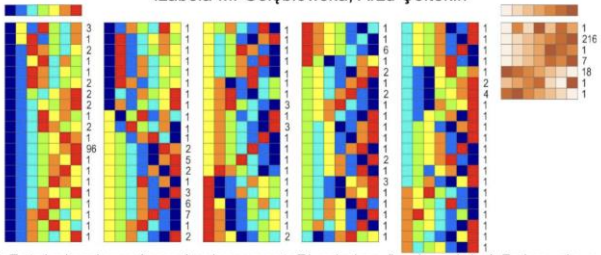


Figure 1. Tested color schemes (top row) and responses to T1: order hues (in columns below). Each row shows a unique sequence provided by at least one participant (counts are shown next to each set). Participants ordered the colors from "min to max" (left to right) purely based on their perceptual associations for the seven hues. We see 101 different orders for the rainbow and seven for the sequential schemes. The 'correct' sets are shown on top.

Abstract—After demonstrating that rainbow colors are still commonly used in scientific publications, we comparatively evaluate the rainbow and sequential color schemes on choropleth and isarithmic maps in an empirical user study with 544 participants to

ISPRS Journal of Photogrammetry and Remote Sensing 194 (2022) 195–208

Contents lists available at ScienceDirect

ISPRS Journal of Photogrammetry and Remote Sensing

journal homepage: www.elsevier.com/locate/isprsjprs

What's wrong with the rainbow? An interdisciplinary review of empirical evidence for and against the rainbow color scheme in visualizations

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[b] Institute of Interactive Technologies, University of Applied Sciences and Arts Northwestern Switzerland, Switzerland

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Rainbow colors
Pseudocoloring
Data visualization
User studies

ABSTRACT

Rainbow color scheme is popularly used across the board in many scientific disciplines for visualizing data, yet heavily debated in visualization literature. In this paper, we first report an interdisciplinary visualization survey examining the prevalence rainbow color scheme use in scientific publications including a temporal analysis. Then we consolidate findings from empirical studies on the subject to better understand why and precisely when the rainbow color scheme might impair human performance with visualizations. Consequently, we systematically document and analyze the consequences of using the rainbow color scheme based on over 37,000 figures in 11,800 papers in information visualization, neuroscience, hydrology, geography, remote sensing and planetary science. Our findings reveal that while the rainbow scheme appears less and less in visualization-related publications, it remains popular in other scientific domains including remote sensing and planetary sciences (strikingly fourteen times more frequent in remote sensing and planetary sciences than in information visualization outlets). We also find that conflicting findings about human performance with the rainbow color scheme is most likely explained by what the users are asked to do with it (i.e., task type). We detail and typify tasks used in the related empirical work in an effort to organize the current understanding on the subject, and translate it to practicable recommendations. We believe our review and analyses bring clarity and nuance to "the rainbow debate" and enable better-informed visualization advice.

1. Introduction

The rainbow (spectral) color scheme (RC) is commonly used for color

-ArcGIS or QGIS- for choropleth maps). Possibly because of these mismatches between theory and practice, the RC has been repeatedly a subject of research and debate in visualization communities (e.g. Bor-

References:

https://www.visualisingdata.com/resources/

Borkin M.A., Gajos K., Peters A., Mitsouras D., Melchionna S., Rybicki F., Feldman C., Pfister H. 2011. “Evaluation of Artery Visualizations for Heart Disease Diagnosis.” IEEE Transactions on Visualization and Computer Graphics 17 (12): 2479–88.

Brewer, C. A., MacEachren, A. M., Pickle, L. W., & Herrmann, D. (1997). Mapping mortality: Evaluating color schemes for choropleth maps. Annals of the Association of American Geographers, 87(3), 411–438.

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