Enhancing Visual Exploration by Appropriate Color Coding

Petra Schulze-Wollgast, Christian Tominski, and Heidrun Schumann
University of Rostock, Germany

-

The 13th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision,
Plzen, Czech Republic
February 3, 2005

Outline

- Introduction & related work
- Concepts for enhanced color coding
- Considering comparison tasks
- Example: Visualizing human health data
- Conclusion & future work

Introduction & Related Work

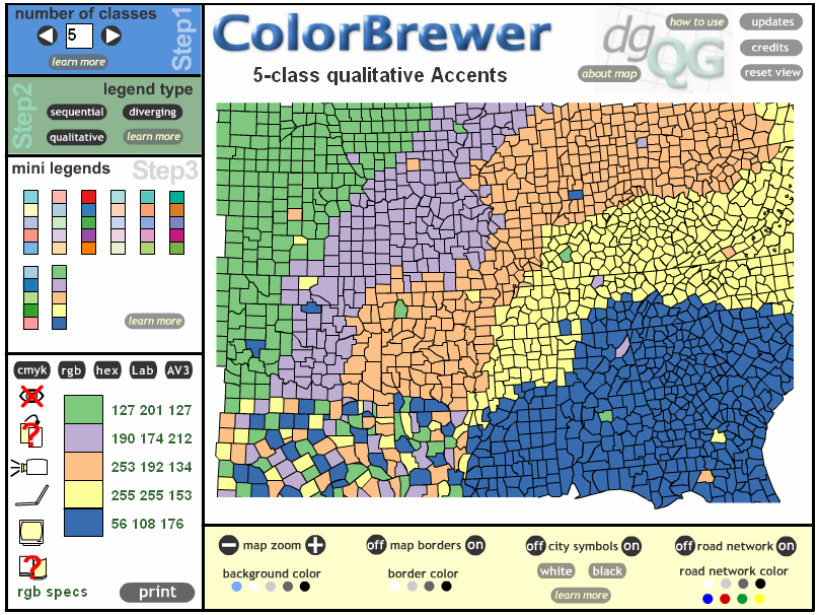
- Enormous capabilities of human visual system
- Color spontaneously recognized
  - ➔ Visualization effective means for data exploration and analysis
- Fundamental visualization technique: color coding
- However, color coding often
  - Provided in a limited way only
  - Not used effectively
- Common mistakes
  - Using of default color scales only
  - No consideration of data characteristics, human perception, or visualization aims and tasks

Introduction & Related Work

Perceptual color scales for categorical data by Cynthia Brewer (1994 and 2003)

www.colorbrewer.org

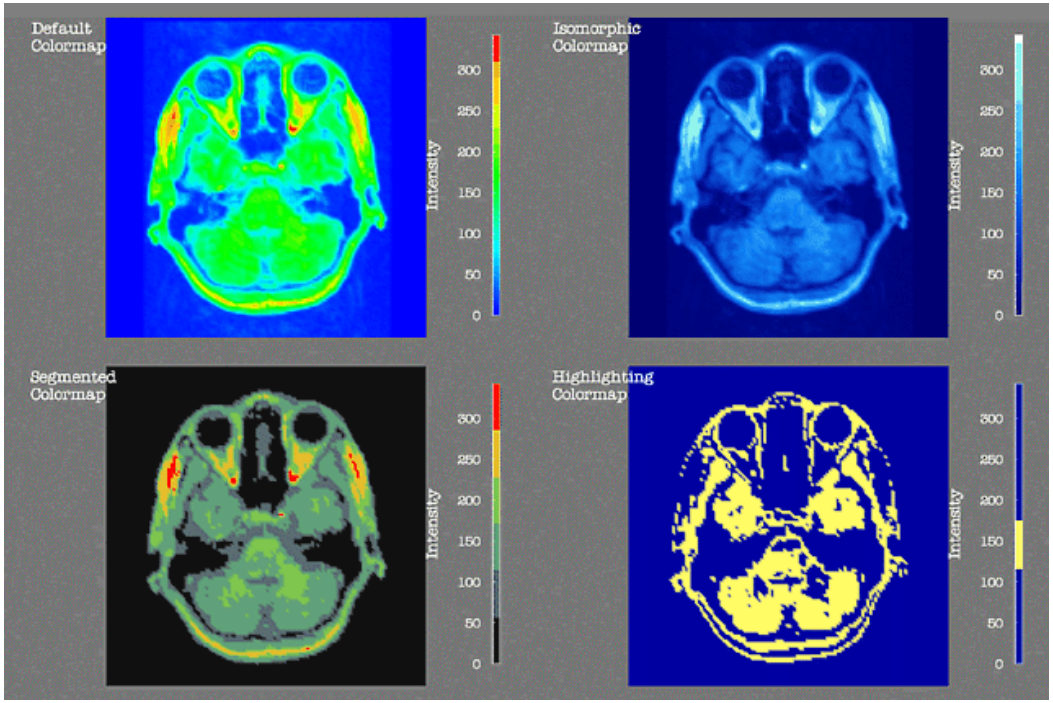
- For data sets with up to 12 categories
- Evaluated against different output media and color blindness



Introduction & Related Work

Perceptual color scales for numerical data by Rogowitz, Treinish, and Bergman (1995, 1996, and 1998)

- Evaluated against different visualization tasks, data type, and spatial frequency
- Rule-based system for automatic color scale selection “PRAVDAColor”



Concepts For Enhanced Color Coding

- How to use color efficiently for visualization still open problem
- Aim: Enhance visual data exploration by appropriate color coding
- Key issues:
  - Use evaluated perceptual color scales,
  - Consider
    - Data characteristics (scaling of value range, statistical characteristics)
    - Perceptual context of user and output media (color blindness, CRT, LCD, projector)
    - Visualization aims and tasks
  - Provide a general framework

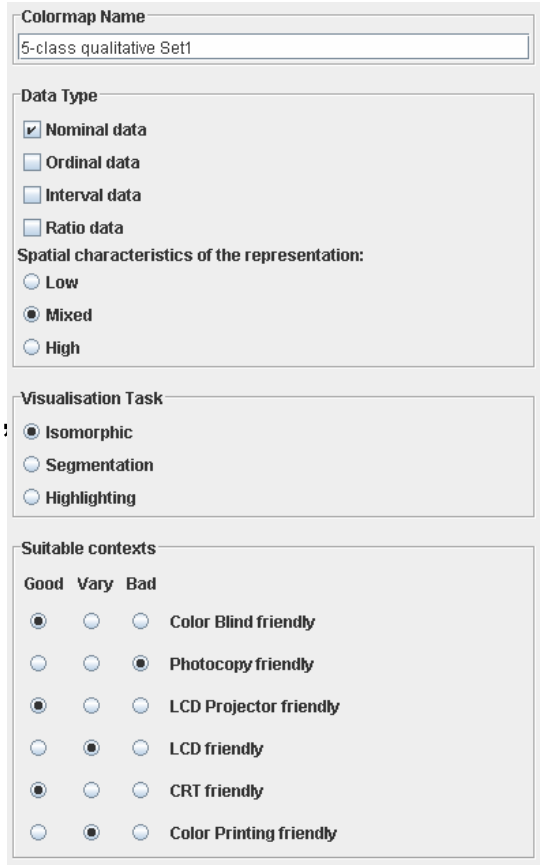
Concepts For Enhanced Color Coding

General Approach

1. Automatic color scale selection (Combination of approach by Rogowitz, Treinish, Bergman with proposals by Brewer)
2. Extraction of statistical meta data
3. Adaptation of chosen color scale according to extracted meta data
4. Creation of expressive color legend

Concepts For Enhanced Color Coding

1. Automatically select effective color scale from a collection of evaluated color scales based on
   - Scaling of value range (nominal, ordinal, numeric)
   - Output media
   - Color blindness
   - Visualization task



Concepts for Enhanced Color Coding

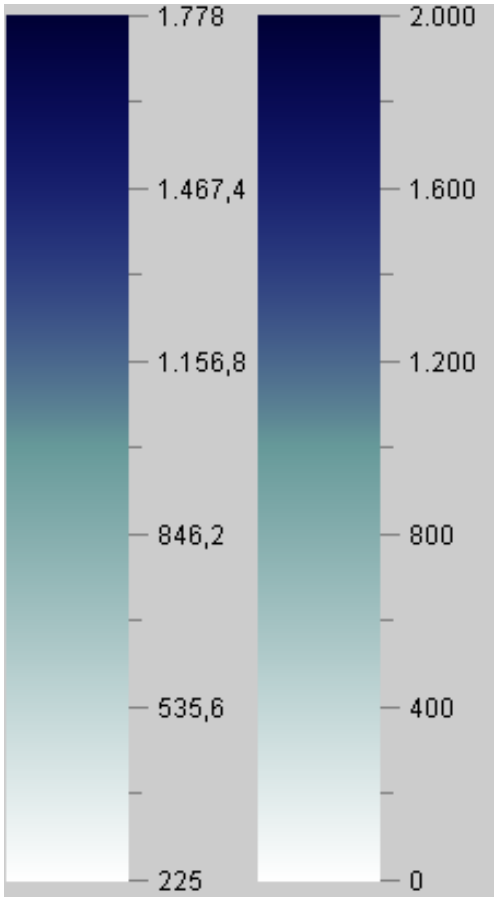
2. Extraction of statistical meta data

- Enables adaptation of chosen color scale in 3.)
- Statistical meta data in combination with expressive color legend helps conveying data characteristics
- Use statistics: average, median, min, max, quartiles, skewness

Concepts For Enhanced Color Coding

3. Adaptation of color scale

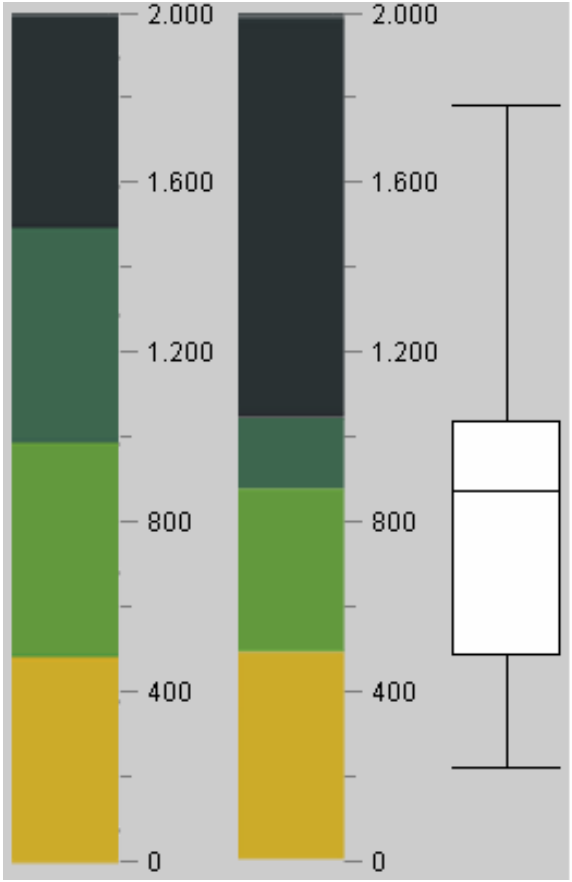
- Value range expansion
  - Ease comprehension of color-value mapping
  - Ensure a certain degree of comparability for dynamic data sets with varying maximum values



Concepts For Enhanced Color Coding

3. Adaptation of color scale

- Control point adjustment
  - Adjust control points of color scale depending on visualization task and meta data
  - Useful for segmentation and highlighting tasks

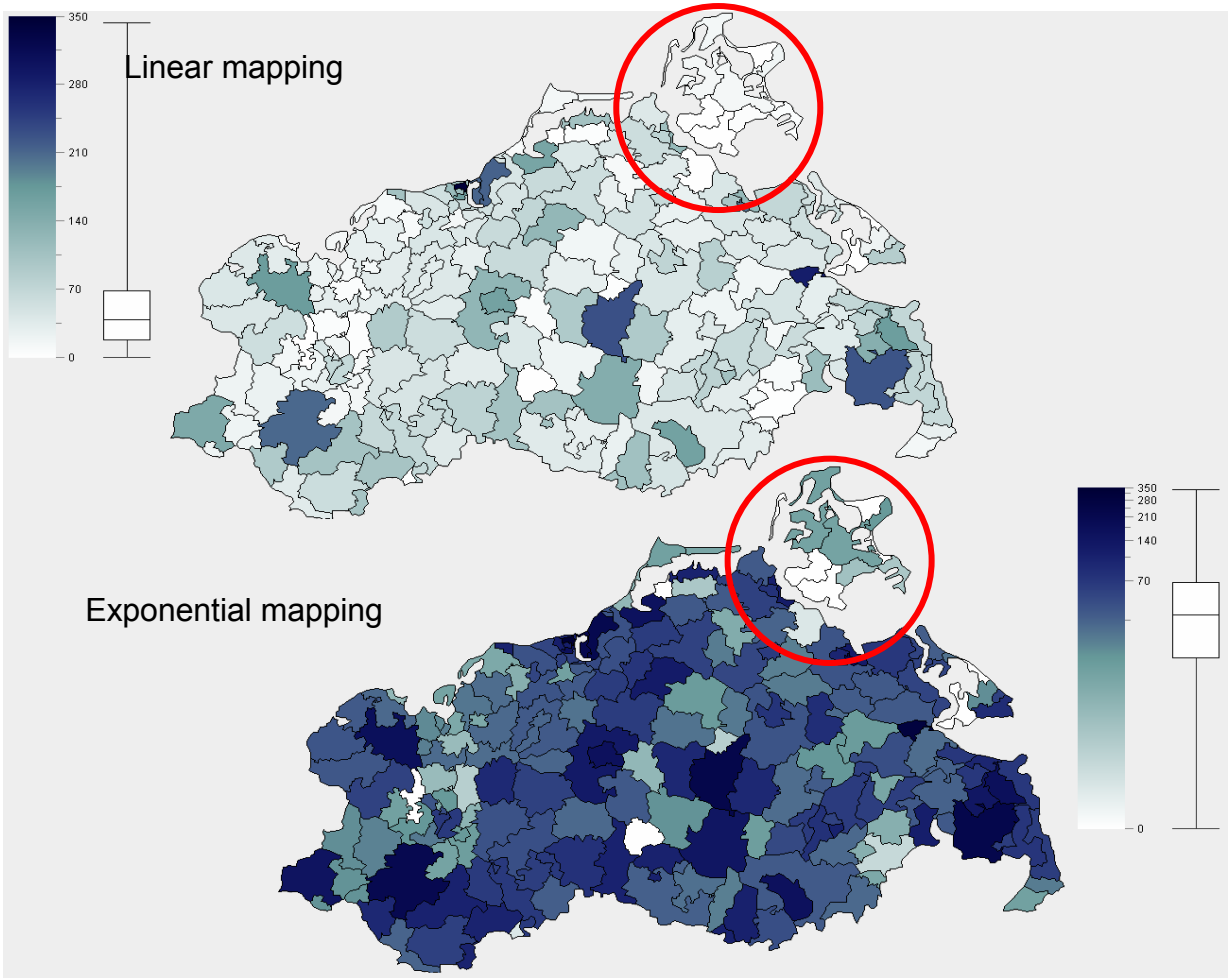


Concepts For Enhanced Color Coding

3. Adaptation of color scale

- Alteration of interpolation function
  - Unfortunate value distributions make use of color difficult
  - Use logarithmic or exponential instead of linear interpolation
  - Decision based on skewness of value distribution

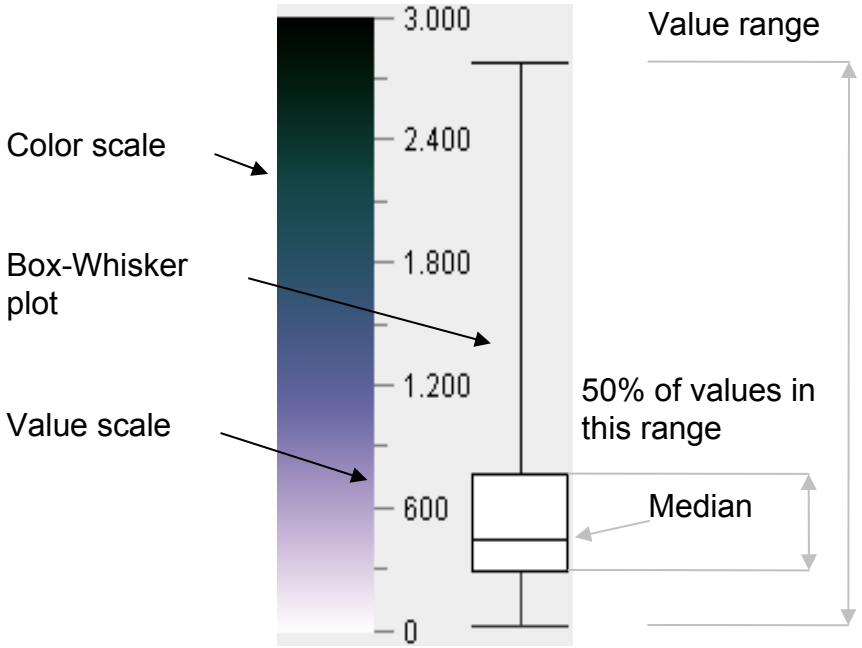
Concepts For Enhanced Color Coding



Concepts For Enhanced Color Coding

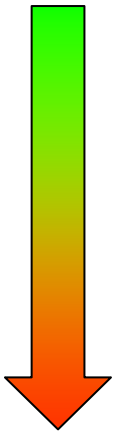
4. Creation of expressive color legend

- Utilize Box-Whisker plot to allow insight into value distribution



Considering Comparison Tasks

- Comparison is essential task in visualization
- Different kinds of comparisons:
  - Intercomparison in one single visualization
  - Comparison in one single visualization session
  - Comparison among multiple visualizations sessions
  - Long term comparisons.



Difficulty in supporting comparison tasks

- How to support these tasks with appropriate color coding?

Considering Comparison Tasks

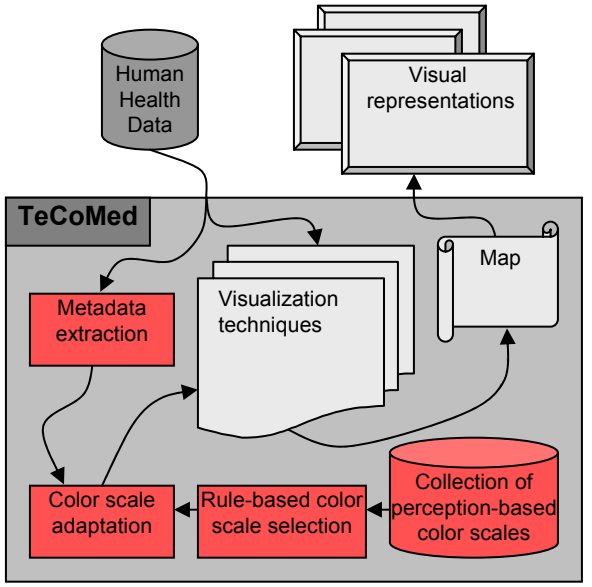
Guidelines:

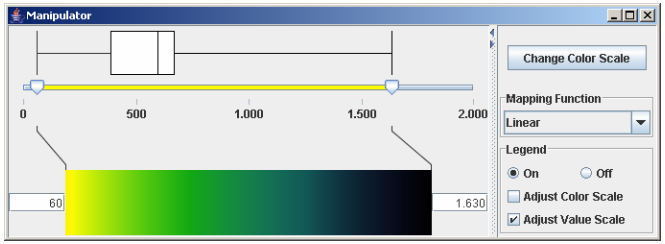
- Utilize automatic color scale selection, meta data, and color scale adaptation as suggested (especially value range expansion is useful)
- Use only one color scale where possible
- Use same colors for same data attributes
- Supporting comparison by: “*ColorMemory*”
  - Associative memory
  - Collects frequency of use of color scales in combination with data attributes
  - Automatically choose color scales of frequent use

Example: Visualizing Human Health Data

System for visualizing data on maps

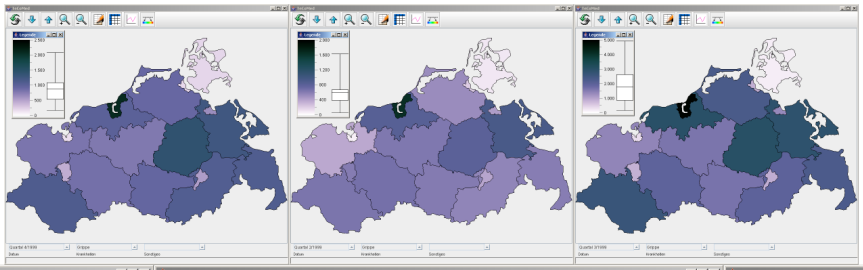
- Support users by providing verbalizations of visualization tasks (e.g. “Show me regions with similar data values”, “I want to compare areas of the map”)
- Automatic color scale selection and adaptations based on user chosen aim
- Interactive color scale manipulation for advanced users



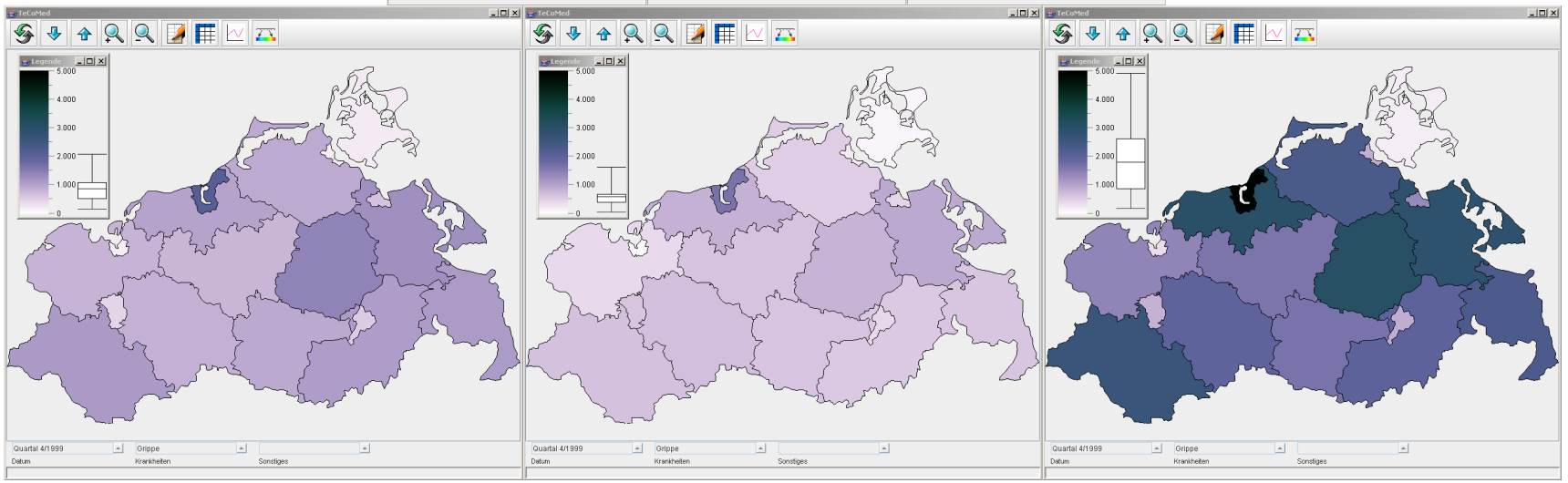


Example: Visualizing Human Health Data

Each view a separate color scale



Comparison misleadingly shows similarity



Common color scale for views
Each view adapted color legend

Comparison reveals differences clearly

Conclusion

- Enhanced color coding for visual exploration
  - Automatic selection from a collection of perceptual color scales
  - Consideration of statistical meta data for adapting chosen color scale expressively
  - Expressive color legend for easing use of color coding in visualization
- Support of essential comparison tasks
- Realization of the approach for visualization of human health data

Future work & References

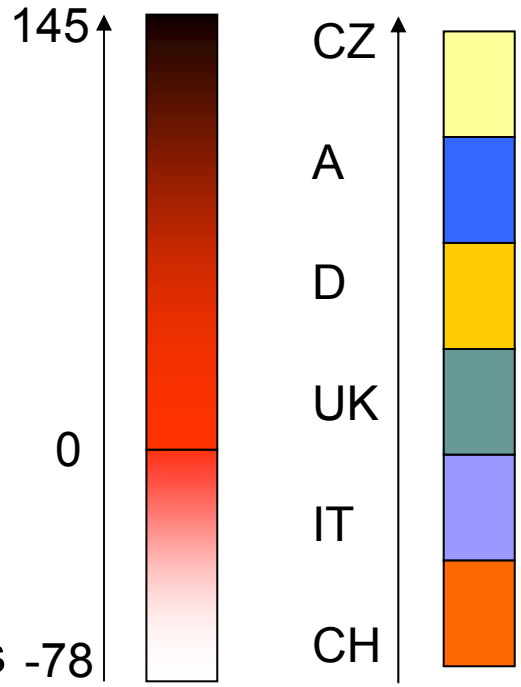
- Further automatic adaptations based on further meta data
- Consideration of color-size-relation on mobile devices
- Integration of more verbalizations for user tasks and aims
- Evaluation of methodology during research project

References

- Brewer, C.A.: *Color Use Guidelines for Mapping and Visualization*, 1994.
- Bergman, L., Rogowitz, B.E., and Treinish, L.A.: *A Rule-based Tool for Assisting Colormap Selection*, 1995.
- Rogowitz,B.E. and Treinish, L.A.: *How NOT to Lie with Visualization*, 1996.
- Rogowitz, B.E. and Treinish, L.A.: *Data Visualization: The End of the Rainbow*, 1998.
- Harrower, M.A. and Brewer, C.A.: *ColorBrewer.org: An Online Tool for Selecting Color Schemes for Maps*, 2003.

Color Scales

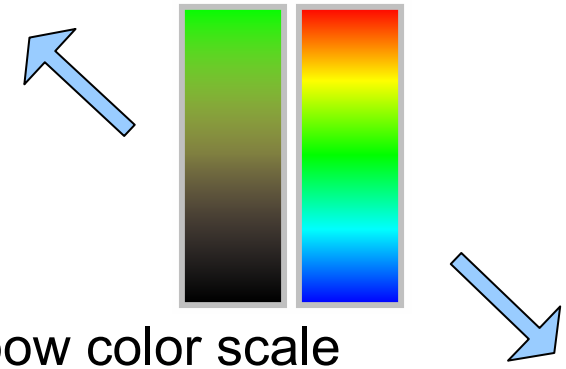
- Control point
  - Maps data value to color
- Color scale
  - Consists of at least 2 control points
  - Interpolation function
- Legend
  - Establish cognitive binding of data values and colors
  - Necessary for understanding



Color scales for numerical and categorical data

Color Scales

- Common mistakes
  - Using RGB color space (technical) instead of perceptual color spaces like HSV
  - Color scale varies in hue, saturation, AND brightness



  - Using the rainbow color scale
  - Color variations not recognized as linear