

Easy colorblind-safe typesetting

General guidelines and a helpful \LaTeX package

20.7.2024

Simon Pfahler

University of Regensburg

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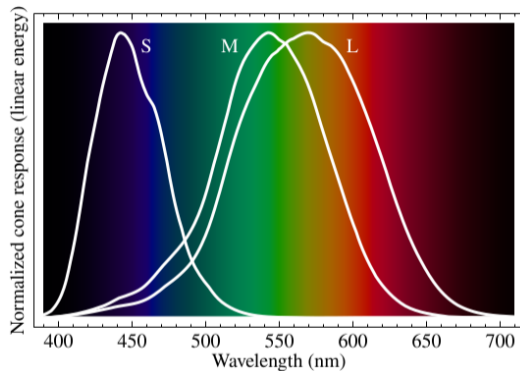
General guidelines and a helpful \LaTeX package

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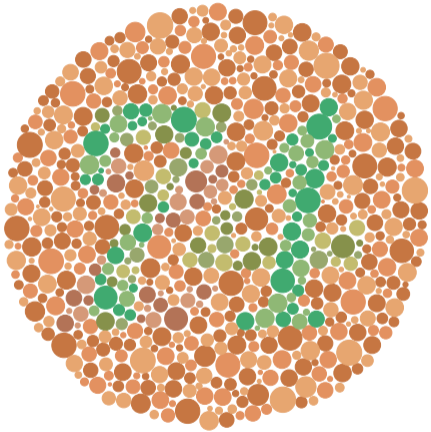
Color vision deficiencies

- ▶ Human color vision relies on three types of cone cells
- ▶ Atypicalities in the sensitivity of cone cells are called *Color vision deficiencies* (CVDs)
- ▶ Roughly 5% of people suffer from a CVD
- ▶ We will focus on color blindness, i.e. the absence of one or more cone cells

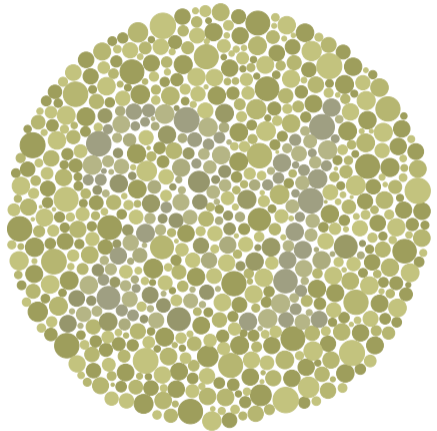


Source: <https://commons.wikimedia.org/wiki/File:Cone-fundamentals-with-srgb-spectrum.svg>

Color blindness simulation

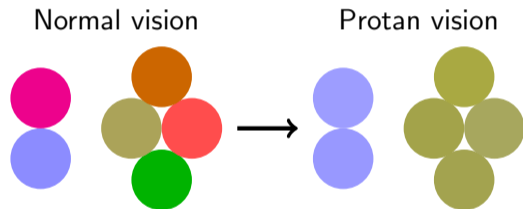


Normal vision



Protan vision (missing L cones)

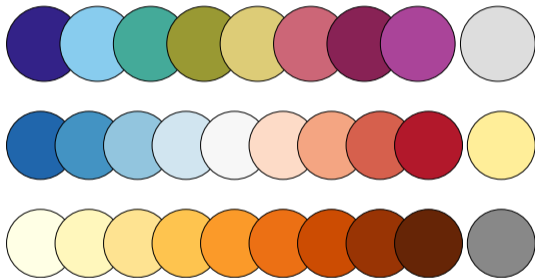
Colorblind-safe design



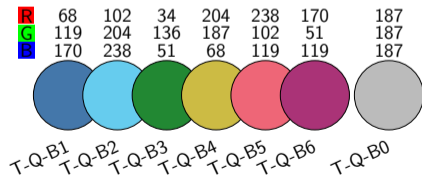
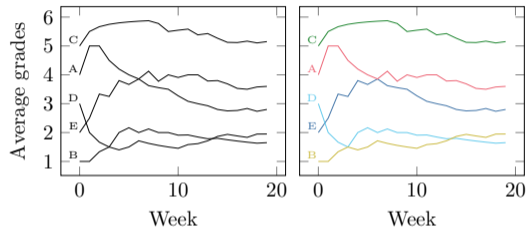
- ▶ Some color combinations are indistinguishable for people with CVDs
- ▶ The *color scheme* used in a *visual unit* should therefore be chosen carefully

Types of color schemes

- ▶ There are different types of color schemes used to visualize different types of data
- ▶ To understand them, we follow five students through their 20 week long semester



Qualitative color schemes



- ▶ First we want to know the evolution of each student's average grade
- ▶ Color is introduced to help distinguish the lines
- ▶ *Qualitative color schemes* provide colors that are easy to distinguish, without any connection between colors

Diverging color schemes

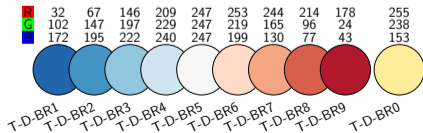
- ▶ Next we want to see all individual grades of the students
- ▶ Color is again added to aid with the interpretation
- ▶ *Diverging color schemes* provide a continuous range of colors where the middle point is considered “neutral”

A	4	6	5	3	3	3	3	6	1	6	3	5	4	1	4	2	1	3	5	4
B	1	1	2	2	1	2	3	1	1	1	1	3	2	3	4	3	1	1	4	2
C	5	6	6	6	6	6	6	6	5	3	6	6	3	6	3	3	5	6	4	6
D	3	1	1	1	4	3	1	3	1	2	1	2	1	1	2	1	1	1	1	2
E	2	3	5	3	6	3	5	2	3	3	1	1	2	2	1	2	3	4	1	4

Week

A	4	6	5	3	3	3	3	6	1	6	3	5	4	1	4	2	1	3	5	4
B	1	1	2	2	1	2	3	1	1	1	1	3	2	3	4	3	1	1	4	2
C	5	6	6	6	6	6	6	6	5	3	6	6	3	6	3	3	5	6	4	6
D	3	1	1	1	4	3	1	3	1	2	1	2	1	1	2	1	1	1	1	2
E	2	3	5	3	6	3	5	2	3	3	1	1	2	2	1	2	3	4	1	4

Week



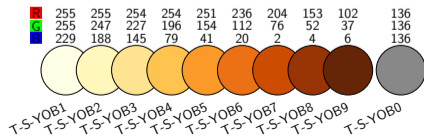
Sequential color schemes

A	2	1	3	3	2	0	2	3	1	1	4	0	3	0	0	1	2	2	1	1
B	2	5	6	9	6	6	5	5	7	3	3	4	3	4	3	6	6	4	5	2
C	6	6	13	6	9	3	1	4	6	3	5	6	5	1	4	6	1	6	6	6
D	6	8	7	4	12	6	5	8	7	6	6	4	8	8	4	15	10	6	3	6
E	11	6	10	4	8	6	5	5	5	7	7	5	6	7	7	4	8	7	6	8

Week

A	2	1	3	3	2	0	2	3	1	1	4	0	3	0	0	1	2	2	1	1
B	2	5	6	9	6	6	5	5	7	3	3	4	3	4	3	6	6	4	5	2
C	6	6	13	6	9	3	1	4	6	3	5	6	5	1	4	6	1	6	6	6
D	6	8	7	4	12	6	5	8	7	6	6	4	8	8	4	15	10	6	3	6
E	11	6	10	4	8	6	5	5	5	7	7	5	6	7	7	4	8	7	6	8

Week



- ▶ Lastly, our students ask a number of questions each week
- ▶ As before, color helps interpret the graphic faster
- ▶ *Sequential color schemes* provide a continuous range of colors where one end is considered “neutral”, whereas the other is considered “extreme”

Guidelines

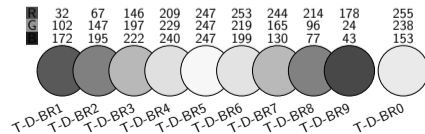
- ▶ There are many different forms of CVDs, so a color scheme can never be easily distinguishable under all of them
- ▶ Using a few rules, we can make sure that our documents are colorblind-safe

A	4	6	5	3	3	3	3	6	1	6	3	5	4	1	4	2	1	3	5	4
B	1	1	2	2	1	2	3	1	1	1	1	3	2	3	4	3	1	1	4	2
C	5	6	6	6	6	6	6	6	5	3	6	6	3	6	3	3	5	6	4	6
D	3	1	1	1	4	3	1	3	1	2	1	2	1	1	2	1	1	1	1	2
E	2	3	5	3	6	3	5	2	3	3	1	1	2	2	1	2	3	4	1	4

Week

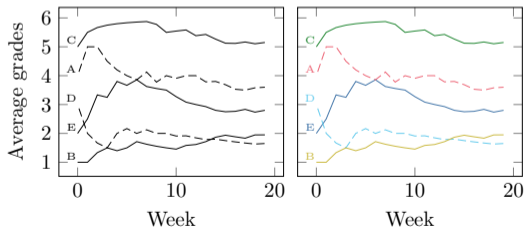
A	4	6	5	3	3	3	3	6	1	6	3	5	4	1	4	2	1	3	5	4
B	1	1	2	2	1	2	3	1	1	1	1	3	2	3	4	3	1	1	4	2
C	5	6	6	6	6	6	6	6	5	3	6	6	3	6	3	3	5	6	4	6
D	3	1	1	1	4	3	1	3	1	2	1	2	1	1	2	1	1	1	1	2
E	2	3	5	3	6	3	5	2	3	3	1	1	2	2	1	2	3	4	1	4

Week



Rule 1:

Always provide information in more ways than just color.



- ▶ Color perception is unreliable, so do not rely on it in your documents
- ▶ Use patterns or text to provide the information encoded in color
- ▶ Following this rule, your documents are guaranteed to be colorblind-safe

Rule 2:

Stick to a color scheme.

(a) Do not mix colors within a scheme.

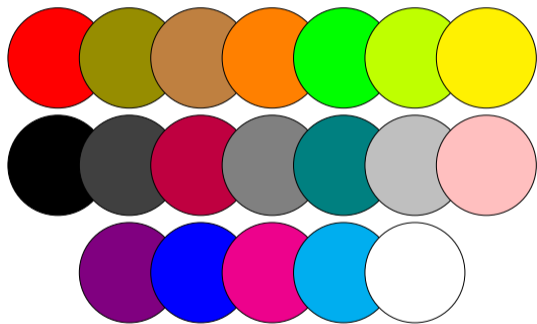
(b) Do not use shades of colors.

Rule 3:

Do not use color for information and aesthetics simultaneously.

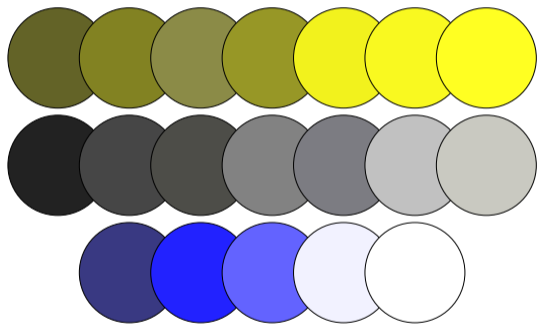
Rule 4:

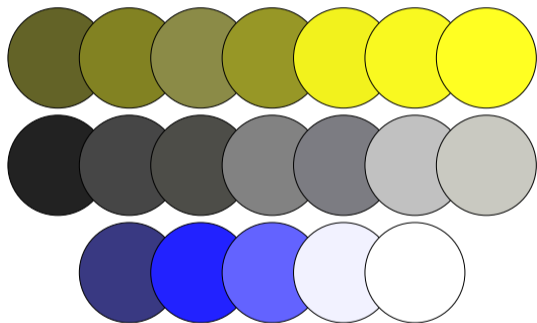
Do not use rainbow color schemes.



- ▶ There are 19 built-in named colors always available in `xcolor`
- ▶ Many \LaTeX packages use these colors directly
- ▶ First warning sign: Their RGB values are e.g. $(1, 0, 0)$ for `red` or $(0, 1, 0)$ for `green`

Colors in L^AT_EX





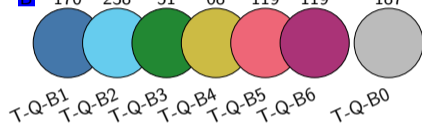
- ▶ **Call to developers:**
If your package uses colors, please think about what standard colors to use, because many people will not modify them

The colorblind package

- ▶ Existing tools for colorblind-safe colors require manual definition of colors in \LaTeX
- ▶ My \LaTeX package colorblind tries to fill that gap, providing:
 - ▶ Color definitions of various colorblind-safe schemes
 - ▶ Continuous pgf colormaps for schemes that can be interpolated

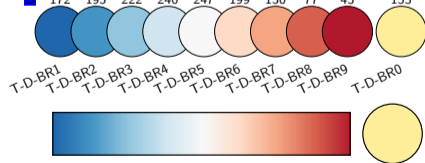
Tol's Qualitative Bright scheme

R	68	102	34	204	238	170	187
G	119	204	136	187	102	51	187
B	170	238	51	68	119	119	187

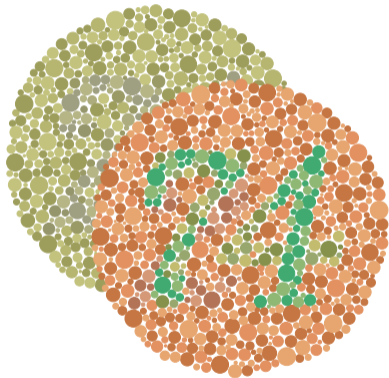


Tol's Diverging Blue-Red scheme

R	32	67	146	209	247	253	244	214	178	255
G	102	147	197	229	247	219	165	96	24	238
B	172	195	222	240	247	199	130	77	43	153



Wishlist for the colorblind package









Main goal and motivation was the creation of a CVD simulator directly within \LaTeX

- ▶ This is difficult to achieve, my approaches are:
 - ▶ Redefining the `\color` command:
This is extremely finicky and fails in all kinds of situations, not suitable for anything beyond personal tinkering
 - ▶ Introducing a new color model similar to gray:
This would probably work, but I am not knowledgeable enough for now
- ▶ `\includegraphics` is a whole other problem, to which I do not know if a solution even exists

Help and feedback is greatly appreciated!

References

-  Birch, Jennifer. “Efficiency of the Ishihara Test for Identifying Red-Green Colour Deficiency”. In: *Ophthalmic and Physiological Optics* 17.5 (Sept. 1997), pp. 403–408. ISSN: 0275-5408. DOI: 10.1016/S0275-5408(97)00022-7.
-  Campbell, Alastair et al. *Web Content Accessibility Guidelines (WCAG) 2.2*. 2023. URL: <https://www.w3.org/TR/WCAG22/> (visited on 06/04/2024).
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-  Simunovic, M. P. “Colour Vision Deficiency”. In: *Eye* 24.5 (May 2010), pp. 747–755. ISSN: 1476-5454. DOI: 10.1038/eye.2009.251.
-  Tol, Paul. *Paul Tol's Notes: Colour schemes and templates*. 2021. URL: <https://personal.sron.nl/~pault/> (visited on 06/02/2024).