Easy colorblind-safe typesetting: the colorblind package

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In colorblind-safe documents, the contents are presented in a way that the same information is conveyed to readers regardless of a potential color vision deficiency. This package provides the tools necessary for color-agnostic typesetting in LaTeX. It provides color schemes for a wide range of applications. The most commonly used schemes are qualitative schemes, providing easily distinguishable colors for use in graphics, but also for text coloring or highlighting. Additionally, diverging and sequential schemes are included which can be used for encoding quantitative information in the colors of a graphic. Therefore, colorblind-safeness is incorporated into the writing process, making it both less cumbersome and less error-prone.

Contents

1 Introduction

The **colorblind** package provides the color schemes by Paul Tol [1] and the Okabe Ito color palette [2]. By default, no schemes are loaded. Providing one of the options `Tol` or `OkabeIto` loads all corresponding schemes.

As an example for how to use the colors, we look at the *bright qualitative* color scheme by Tol. fig. 1 shows the colors in the scheme
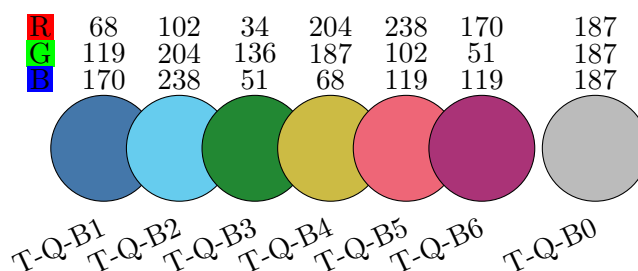

Figure 1: Bright qualitative color scheme by Tol.

All colors in this model start with `T-Q-B`, indicating that it is a scheme by **T**ol, that it is a **q**ualitative scheme, and that it is the **b**right scheme. The colors in the scheme are specified by a number following the scheme name, in this case ranging from `T-Q-B1` to `T-Q-B6` for the non-grey colors. The additional color `T-Q-B0` provides a color that can be used, e.g., to indicate bad data.

There are two reasons why color names are not based on natural color names (e.g., blue):

1. Certain colors (green, red) are often used by people with full color vision to convey certain meanings (good, bad). This meaning is difficult for people with color-deficiencies to pick up. By not using natural color names, it is easier to write color-agnostic documents that do not make use of said connotations.

2. Natural color names can be cumbersome, e.g., when multiple variations of blue are used. It is annoying having to look up if a color is called, e.g., light blue or cyan.

These colors are used the same way as any other colors. To change the text color to `T-Q-B1` for example, use `\color{T-Q-B1}`.

2 Guidelines

On its own, using colorblind-safe colors is not sufficient for making a document truly colorblind-safe. This section provides some general rules to follow for colorblind-safe typesetting.

These rules apply to each visual unit of a document individually. A visual unit may be a graphic, a table or a paragraph of text. It might be advisable to be consistent also between different visual units (e.g., use the same color scheme for all graphics), but this is more of an aesthetic argument and is not necessary for a colorblind-safe document.

The most important rules are, in this order:

1. Do not mix the colors in qualitative schemes!
   Mixing of colors, e.g., `T-Q-B1!50!T-Q-B5` also interferes with the packages intention of providing distinguishable colors.

2. Only use colors from one color scheme for a given visual unit!
   The colors are defined with the purpose of being easily distinguishable, but this is only true within each color scheme. Using colors from multiple schemes therefore defies the point of this package.

3. Do not use shades of colors!
   Saturation and brightness are also used for distinguishability, so mixings involving `white` and `black` should also be avoided.

The first two rules should be ensured in any visual unit. If the need for more colors arises, a different color scheme should be used alltogether. While the third rule should also be followed in most scenarios, there are some situations that might allow for breaking this rule. As an example, consider fig. 2, where the error band is colored with a lighter shade of the original color.
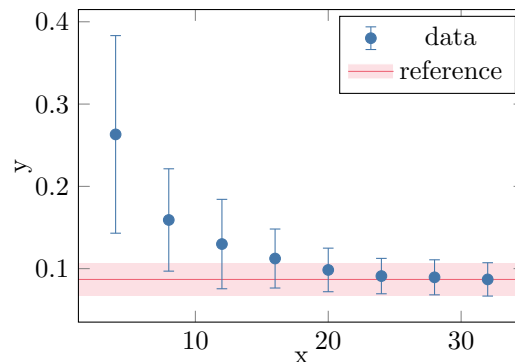

Figure 2: This plot breaks rule 3 by using the shade `T-Q-B5!20` for the error band of the reference.

There are additional guidelines that should be kept in mind when typesetting colorblind-safe documents. Depending on the specific visual unit, they are usually not as vital as the rules stated above. In no particular order, they are:

- Do not convey information only through color!
  When possible, encode the information the color provides also in a different way, e.g., through text, patterns or symbols.

- Do not use color for information and aesthetics simultaneously!
  Color is often also used for aesthetic reasons, e.g., on a scientific poster. While this is ok in principle, do not mix information and aesthetics within the same visual unit, as this makes it more difficult to extract the encoded information.

3 Provided color schemes

3.1 Paul Tol's color schemes
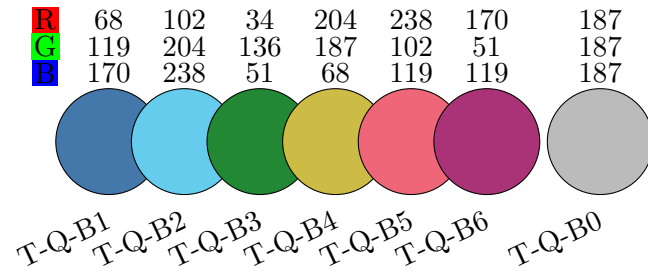
3.1.1 Qualitative color schemes

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

T-Q-B1 T-Q-B2 T-Q-B3 T-Q-B4 T-Q-B5 T-Q-B6 T-Q-B0

Figure 3: Bright qualitative color scheme by Paul Tol [1].

R	255	221	187	0	0
G	255	170	85	68	0
B	255	51	102	136	0

T-Q-HC1 T-Q-HC2 T-Q-HC3 T-Q-HC4 T-Q-HC0
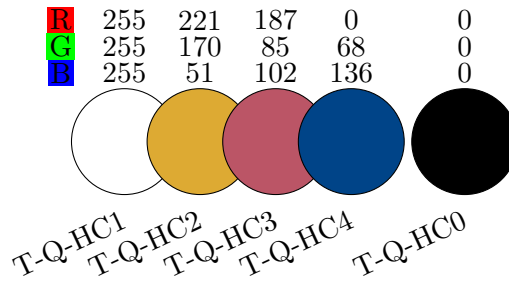
Figure 4: High-contrast qualitative color scheme by Paul Tol [1].

R	0	51	0	238	204	238	187
G	119	187	153	119	51	51	187
B	187	238	136	51	17	119	187

T-Q-V1 T-Q-V2 T-Q-V3 T-Q-V4 T-Q-V5 T-Q-V6 T-Q-V0
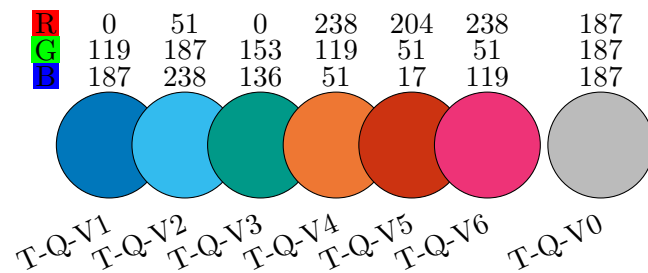
Figure 5: Vibrant qualitative color scheme by Paul Tol [1].

3.1.2 Diverging color schemes

3.1.3 Sequential color schemes

3.2 Okabe Ito qualitative color scheme

3.3 Provided commands

\drawScheme{...} The visualizations of color schemes given in this documentation are created with the
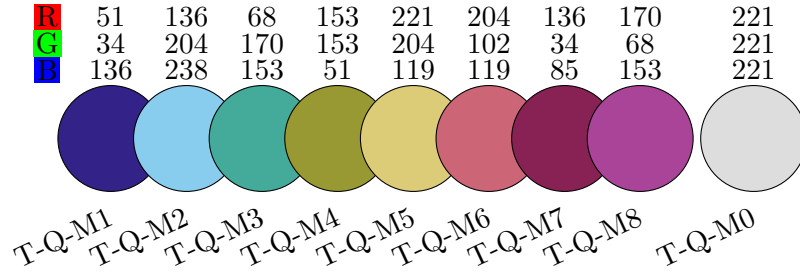
R	51	136	68	153	221	204	136	170	221
G	34	204	170	153	204	102	34	68	221
B	136	238	153	51	119	119	85	153	221

T-Q-M1 T-Q-M2 T-Q-M3 T-Q-M4 T-Q-M5 T-Q-M6 T-Q-M7 T-Q-M8 T-Q-M0

Figure 6: Muted qualitative color scheme by Paul Tol [1].

R	255	238	238	102	153	153	0	0
G	255	204	153	153	119	68	68	0
B	255	102	170	204	0	85	136	0

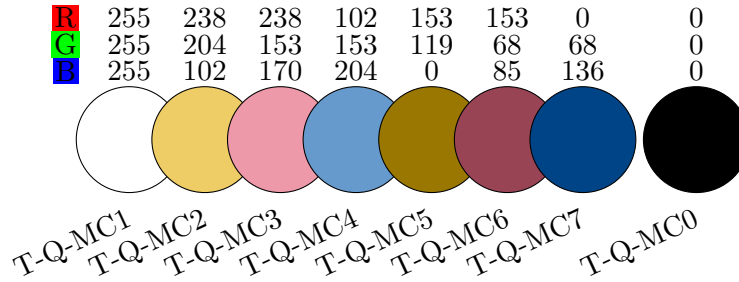T-Q-MC1 T-Q-MC2 T-Q-MC3 T-Q-MC4 T-Q-MC5 T-Q-MC6 T-Q-MC7 T-Q-MC0

Figure 7: Medium-contrast qualitative color scheme by Paul Tol [1].

command `\drawScheme{...}`. Only the prefix of a color scheme should be provided to the command, e.g. `\drawScheme{T-Q-B}` to print the qualitative bright scheme by Tol, as can be seen in fig. 3.

4 Experimental and work in progress

References

[1] Paul Tol. *Paul Tol's Notes: Colour schemes and templates.* 2021. URL: https://personal.sron.nl/~pault/ (visited on 2023-12-29).

[2] Yasuyo G. Ichihara et al. "Color universal design: the selection of four easily distinguishable colors for all color vision types". In: *Color Imaging XIII: Processing, Hardcopy, and Applications.* Ed. by Reiner Eschbach, Gabriel G. Marcu, and Shoji Tominaga. Vol. 6807. International Society for Optics and Photonics. SPIE, 2008, 68070O. URL: https://doi.org/10.1117/12.765420.
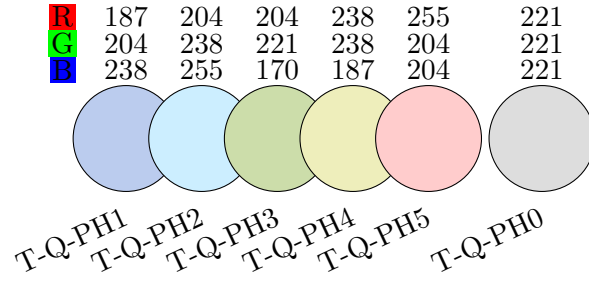
R	187	204	204	238	255	221
G	204	238	221	238	204	221
B	238	255	170	187	204	221

T-Q-PH1 T-Q-PH2 T-Q-PH3 T-Q-PH4 T-Q-PH5 T-Q-PH0

Figure 8: Pale qualitative color scheme by Paul Tol [1], for highlighting only.

R	34	34	34	102	102	85
G	34	85	85	102	51	85
B	85	85	34	51	51	85

T-Q-DT1 T-Q-DT2 T-Q-DT3 T-Q-DT4 T-Q-DT5 T-Q-DT0
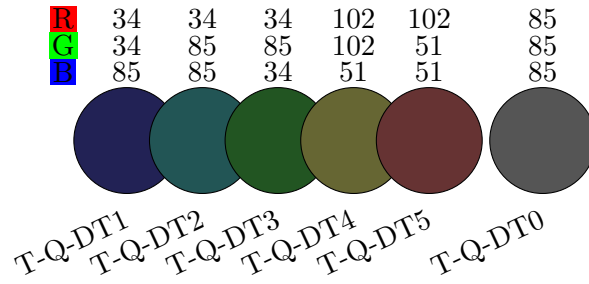
Figure 9: Dark qualitative color scheme by Paul Tol [1], for text color only.

R	119	153	68	187	170	238	238	255	221
G	170	221	187	204	170	221	136	170	221
B	221	255	153	51	0	136	102	187	221

T-Q-L1 T-Q-L2 T-Q-L3 T-Q-L4 T-Q-L5 T-Q-L6 T-Q-L7 T-Q-L8 T-Q-L0
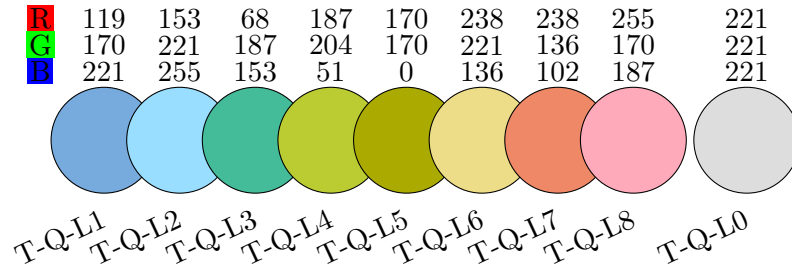
Figure 10: Light qualitative color scheme by Paul Tol [1].

R	54	74	110	152	194	234	254	253	246	221	165	255
G	75	123	166	202	228	236	218	179	126	61	0	255
B	154	183	205	225	239	204	139	102	75	45	38	255

T-D-S1 T-D-S2 T-D-S3 T-D-S4 T-D-S5 T-D-S6 T-D-S7 T-D-S8 T-D-S9 T-D-S10 T-D-S11 T-D-S0
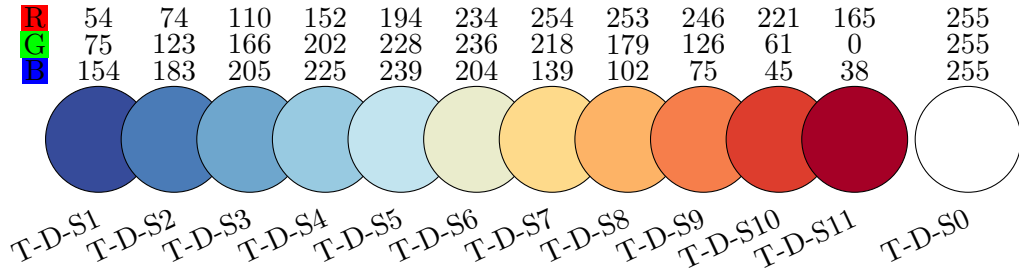
Figure 11: Sunset diverging color scheme by Paul Tol [1].

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

T-D-BR1 T-D-BR2 T-D-BR3 T-D-BR4 T-D-BR5 T-D-BR6 T-D-BR7 T-D-BR8 T-D-BR9 T-D-BR0
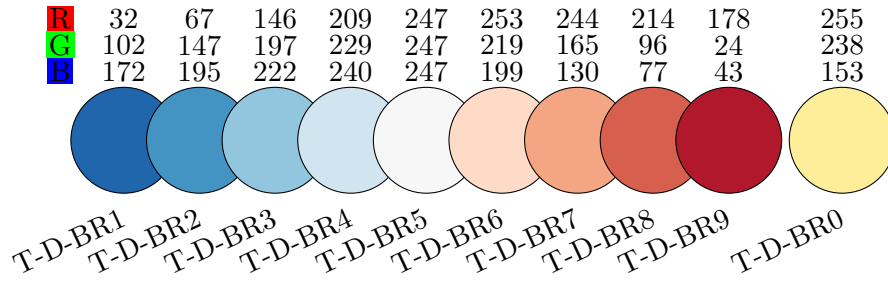
Figure 12: BuRd diverging color scheme by Paul Tol [1].

R	118	153	194	231	247	217	172	90	27	255
G	42	112	165	212	247	240	211	174	120	238
B	131	171	207	232	247	211	158	97	55	153

T-D-PG1 T-D-PG2 T-D-PG3 T-D-PG4 T-D-PG5 T-D-PG6 T-D-PG7 T-D-PG8 T-D-PG9 T-D-PG0
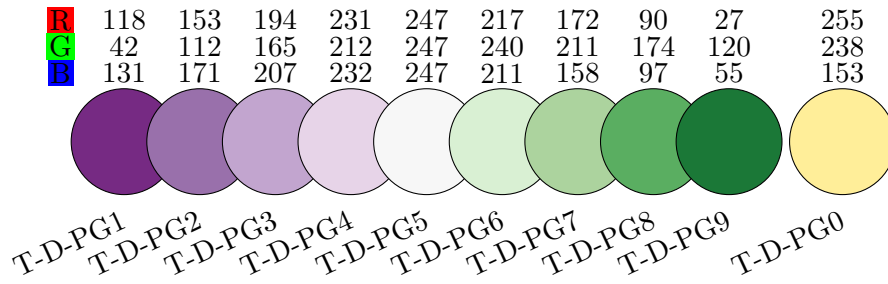
Figure 13: PRGn diverging color scheme by Paul Tol [1].

R	255	255	254	254	251	236	204	153	102	136
G	255	247	227	196	154	112	76	52	37	136
B	229	188	145	79	41	20	2	4	6	136

T-S-YB1 T-S-YB2 T-S-YB3 T-S-YB4 T-S-YB5 T-S-YB6 T-S-YB7 T-S-YB8 T-S-YB9 T-S-YB0
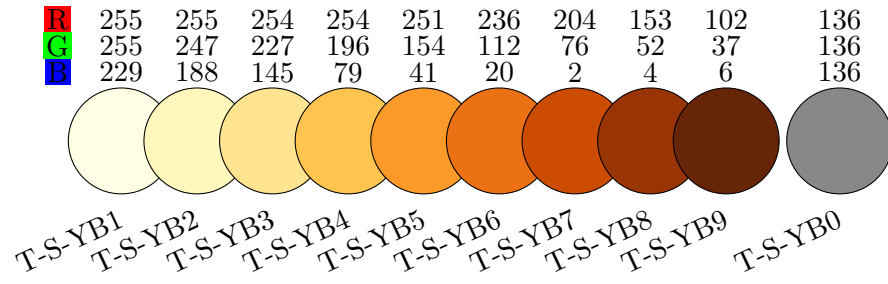
Figure 14: YlOrBr sequential color scheme by Paul Tol [1].

R	209	174	136	25	82	123	78	144	202	247	246	241	232	220	119
G	187	118	46	101	137	175	178	201	224	240	193	147	96	5	119
B	215	163	114	176	199	222	101	135	171	86	65	45	28	12	119

T-S-DR1 T-S-DR2 T-S-DR3 T-S-DR4 T-S-DR5 T-S-DR6 T-S-DR7 T-S-DR8 T-S-DR9 T-S-DR10 T-S-DR11 T-S-DR12 T-S-DR13 T-S-DR14 T-S-DR0
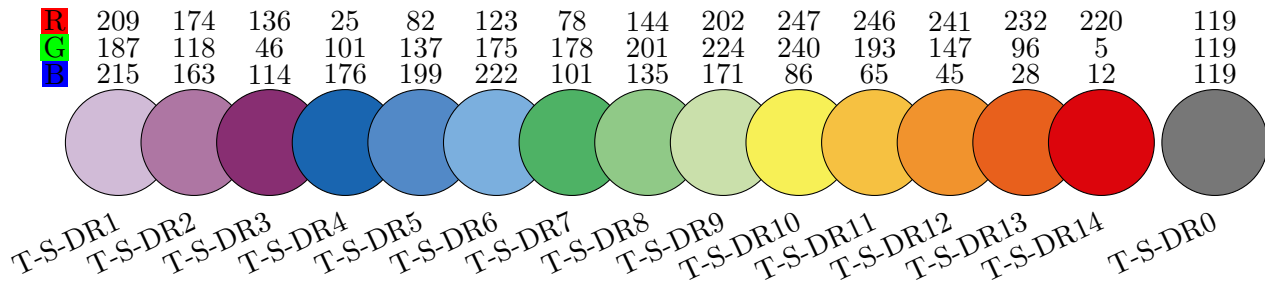
Figure 15: Discrete Rainbow sequential color scheme by Paul Tol [1].

R	230	86	0	240	0	213	204	0
G	159	180	158	228	114	94	121	0
B	0	233	115	66	178	0	167	0

OI1 OI2 OI3 OI4 OI5 OI6 OI7 OI0
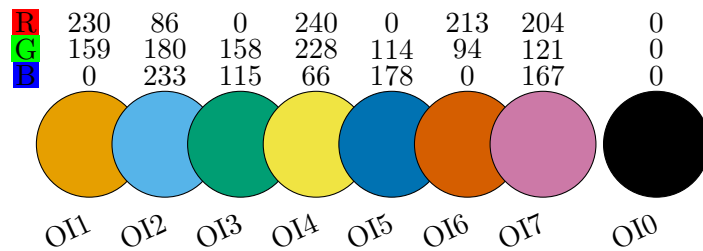
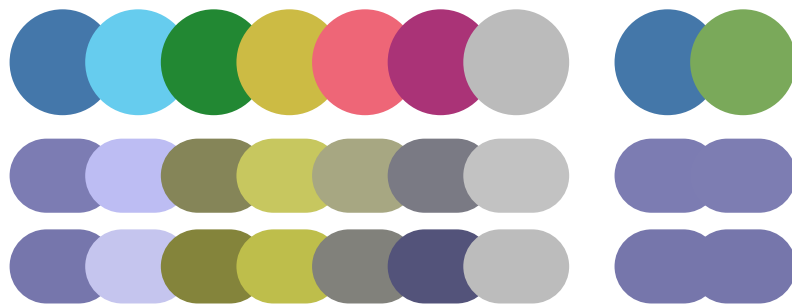Figure 16: Okabe Ito qualitative color scheme [2].

Figure 17: Test for deuteranopia and tritanopia commands: Left shows Tol's bright qualitative scheme, with deuteranopia and tritanopia vision in the second and third row. Right shows two colors with the same numbers in rgb and hsb, where the hsb variant gets translated incorrectly to color-deficient visions.
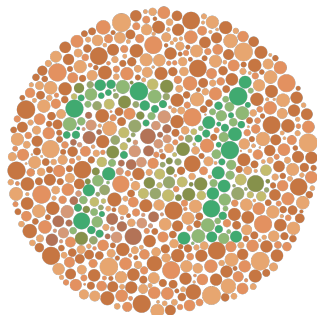

Figure 18: Ishihara colorblindness test, normal vision and without the red channel.