Choosing colours for scientific data presentation

10 simple rules

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Contents

Reminders of properties of human colour vision

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Consequences for colour selection

This talk is about clarity of perception – not about beauty and artistry.
How many colours?

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How many colours?
How many colours?
How many colours?

Colour is largely an illusion!

Only 3!

Colour is largely an illusion!

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Human vision

2 ½-colour vision
Colour constancy
Good resolution
Slow, narrow accommodation (20-2 dioptres)
Good light level range – slow adaption
One shallow fovea
Medium complex retina

Women and men have equally good normal colour vision!
Human opsins

Channels to brain

Lightness \( M+L \)

Hue1 \( M-L \) "redness"

Hue2 \( S - (M+L) \) "blueness"
Human opsins

Channels to brain

<table>
<thead>
<tr>
<th>Lightness</th>
<th>M+L</th>
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<tr>
<td>Hue1</td>
<td>M-L</td>
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<tr>
<td>Hue2</td>
<td>S – (M+L)</td>
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**Lightness** for shape, distance, movement

**Hues** for difference detection

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Colour selection

1. Use large lightness contrast – most important
Colour selection - contrast

ROSE
TORN
Colour selection - contrast

Always check contrast by removing colour
Colour selection

1. Use large lightness contrast – most important
2. Do not overstress the hue channels
Colour selection - hue

Hue channels

M-L \( \text{max} = \text{red} \quad 0 = \text{yellow-green} \quad \text{min} = \text{blue} \)

\( S - (M+L) \) \( \text{max} = \text{blue} \quad 0 = \text{turquoise} \quad \text{min} = \text{yellow-green} \)
Colour selection - hue

M-L max and min  S-(M+L) max and min

Do not put colours with high opposite signals from the same channel together
Humans can **name** about 10 basic colours – 11 in English

Colour selection

1. Use large lightness contrast – most important
2. Do not overstress the hue channels
3. Use basic colours
Use familiar basic colours – they are easier to remember between text and figure.
Colour “blindness”

Red-green blindness about 8% men and 7‰ women (and all cats and dogs).

Blue-yellow blindness about 1‰ both men and women.
Colour selection – colour blindness

- Normal colour vision
- Red-green blindesses (there are four versions)
- Blue-yellow blindness
Colour selection

1. Use large lightness contrast – most important
2. Do not overstress the hue channels
3. Use basic colours
4. Think of the colour-blind
Colour selection – colour blindness

A good order of basic colours could be:

Red – Blue – Black – Orange – Violet – Grey – Brown

Do not expect people to see the difference between Red and Green
Human colour discrimination

150 different hues

200 different lightnesses

150 saturations

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about 4.5 million colours are theoretically different
Colour selection – number of colours

Stressed humans can distinguish 3-4 colours
Colour selection

1. Use large lightness contrast – most important
2. Do not overstress the hue channels
3. Use basic colours
4. Think of the colour-blind
5. Do not use more than 3-4 colours
Colour selection – number of colours

3 colours and two textures are better…

…than 6 colours and one texture.

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Resolution in L and M is 10 times resolution in S in the human fovea
Colour selection

1. Use large lightness contrast – most important
2. Do not overstress the hue channels
3. Use basic colours
4. Think of the colour-blind
5. Do not use more than 3-4 colours
6. Do not use blue for fine details
Colour selection – blue

Use blue with small lightness difference only for big objects.
Colour selection

1. Use large lightness contrast – most important
2. Do not overstress the hue channels
3. Use basic colours
4. Think of the colour-blind
5. Do not use more than 3-4 colours
6. Do not use blue for fine details
7. Use mostly muted colours
Low-saturation colours are good for large areas.
1. Use large lightness contrast – most important
2. Do not overstress the hue channels
3. Use basic colours
4. Think of the colour-blind
5. Do not use more than 3-4 colours
6. Do not use blue for fine details
7. Use mostly muted colours
8. Use bright colours only for small spot signals
Small, bright attention-getters are efficient.
Colour selection – false colours

Lightness image

Hue image

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Colour selection

1. Use large lightness contrast – most important
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3. Use basic colours
4. Think of the colour-blind
5. Do not use more than 3-4 colours
6. Do not use blue for fine details
7. Use mostly muted colours
8. Use bright colours only for small spot signals
9. Beware of false colouring
Colour selection – false colours

Grey-scale is often good enough - Avoid rainbow scale for false colouring. Colour alone is not enough.
Colour selection – false colours

TEM image with viruses

Colour added to enhance viruses

But subtle false colouring can be very useful.

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Colour selection

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8. Use bright colours only for small spot signals
9. Beware of false colouring
10. Beware of compression
Colour selection - compression

Centifolia

No compression

Centifolia

JPG-compression

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Colour selection - compression

JPG-compression favours lightness over colour ⇒

Strong JPG-compression destroys colours!

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Colour selection – 10 points

1. Use large lightness contrast – most important
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9. Beware of false colouring
10. Beware of compression
Heraldic tinctures

Metals
- Or
- Argent

Colours
- Azure
- Gules
- Sable
- Vert

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Heraldic tinctures

Uppsala

Uppland

von Linné

Hedemora

Ljusdal

Söderköping

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Heraldic tinctures

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<td></td>
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Rules:
- Metal on metal – NO*
- Metal on colour – YES
- Colour on metal – YES
- Colour on colour – NO

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Follows ALL the rules!

*Except Kingdom of Jerusalem and the pope

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Finally

The colours you see on your screen will be different on other screens.

The colours you see on your screen will be different from the colours you get on your printer.

The colours you get on your printer will be different from the ones you get from the publisher.

The colours your audience/readers see is an illusion.

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So do not try to be subtle about colour in scientific visualisation – think heraldry!
The End!