Choosing colours for scientific data presentation

—

10 simple rules

Gunilla Borgefors

Centre for Image Analysis

Uppsala University

Contents

Reminders of properties of human colour vision

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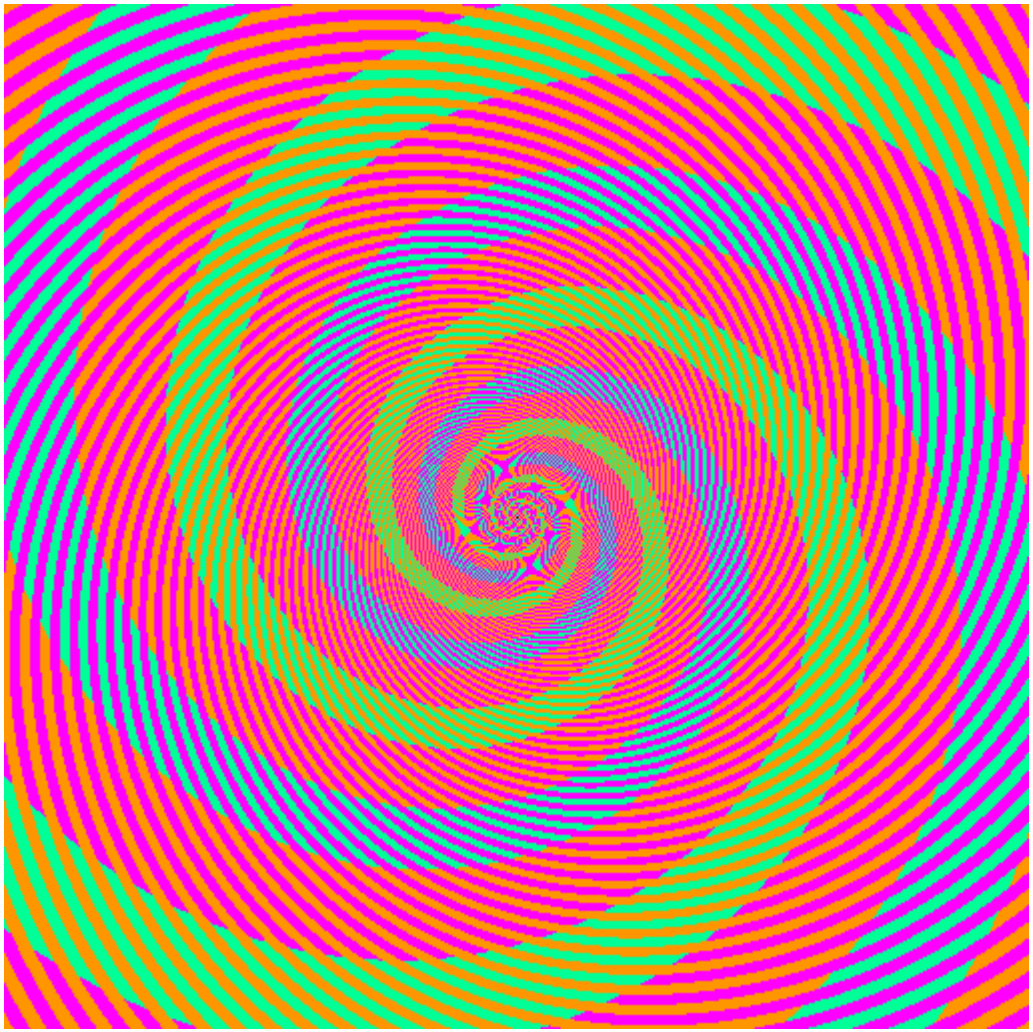
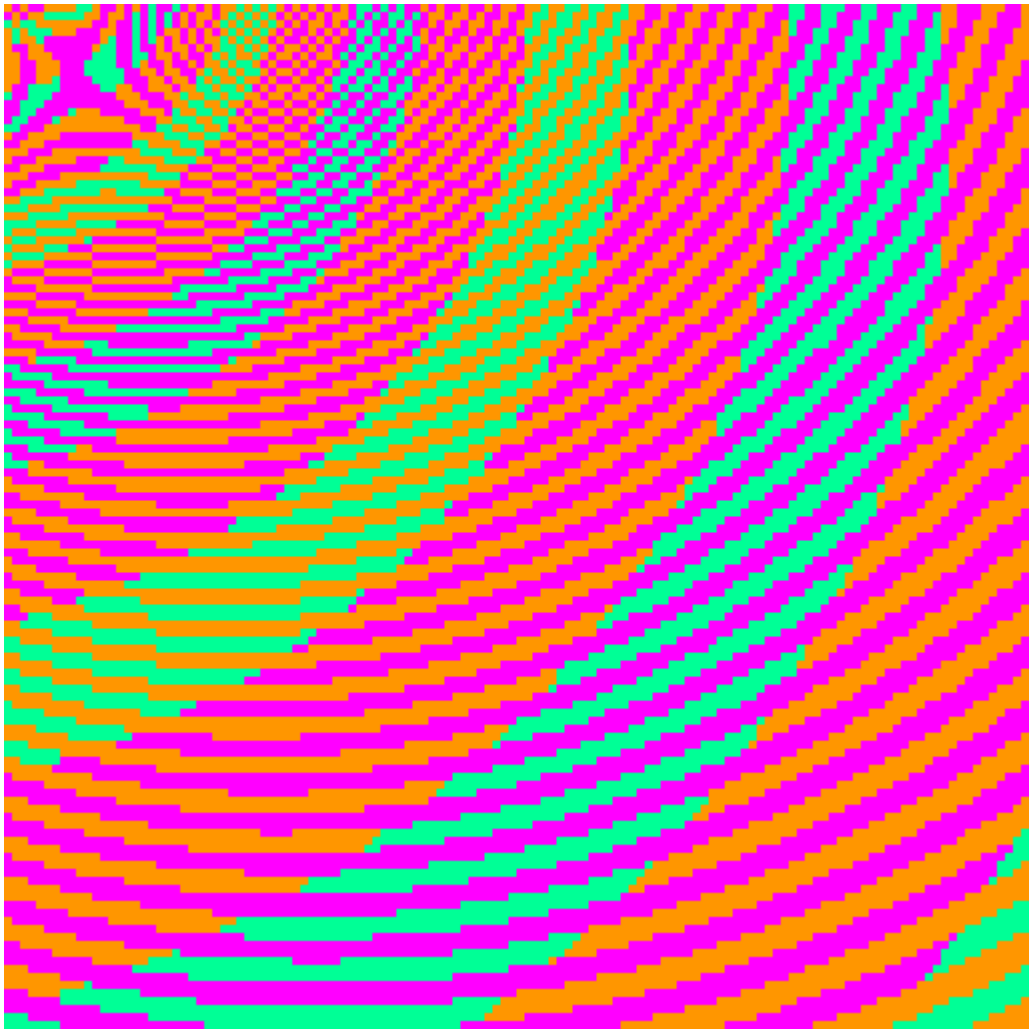
Consequences for colour selection

This talk is about clarity of perception –
not about beauty and artistry.

How many colours?



How many colours?



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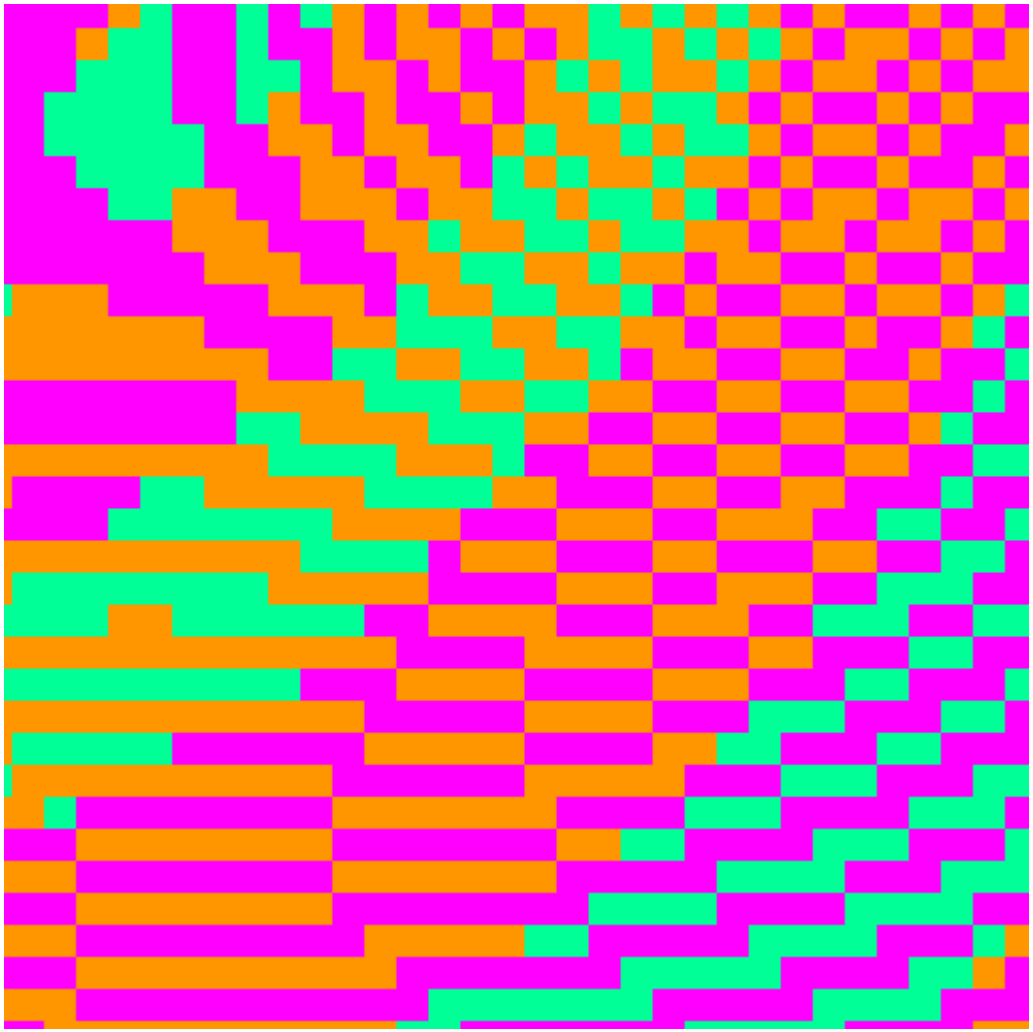

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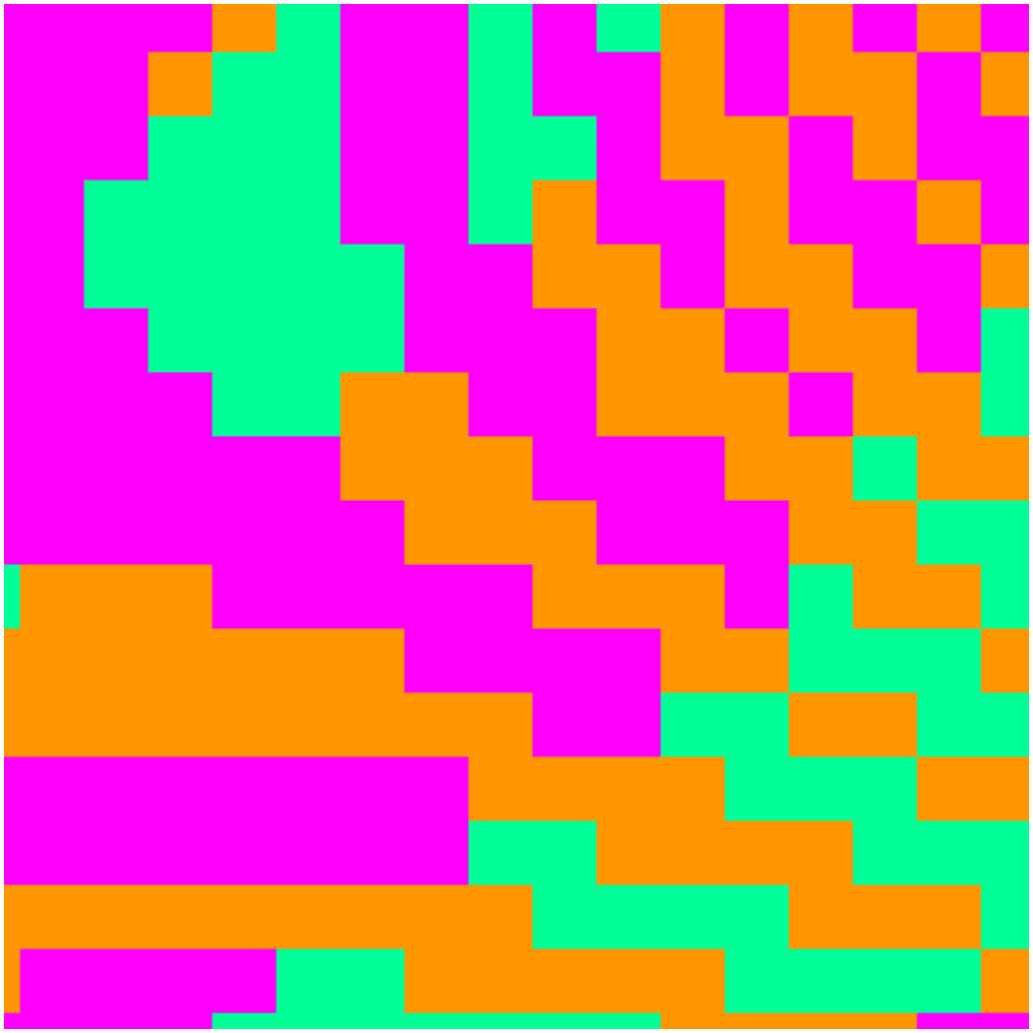
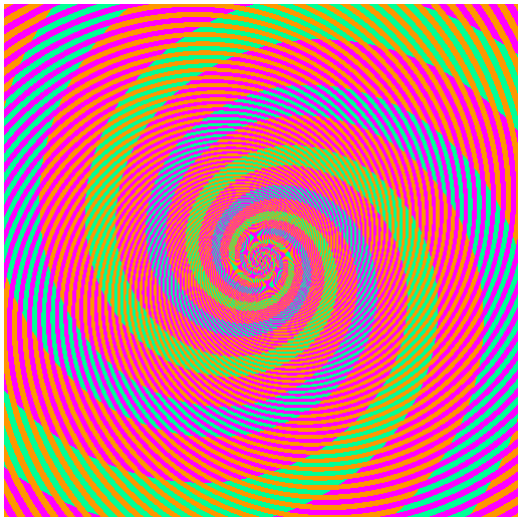
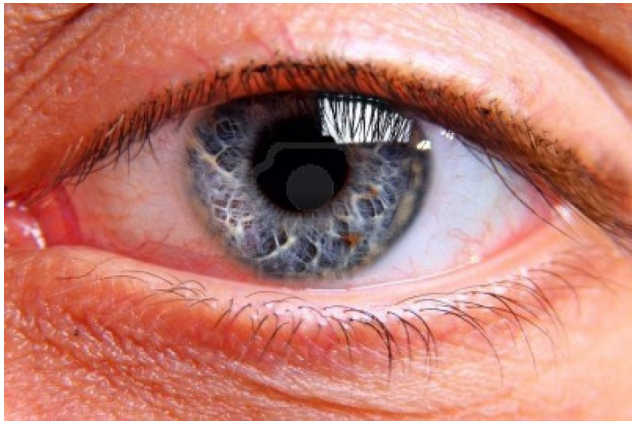


Only 3!



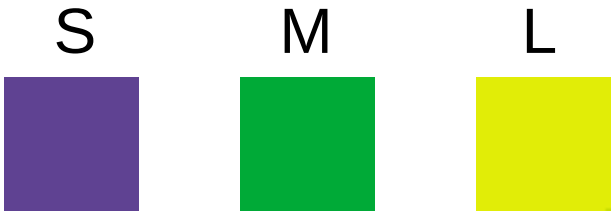
Colour is largely an illusion!

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

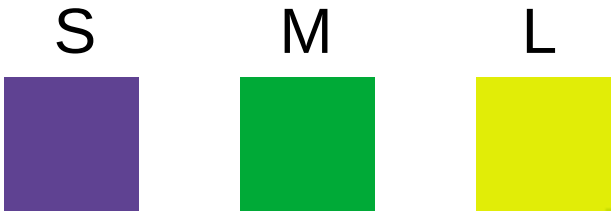
Women and men have equally good normal colour vision!



Human opsins

Channels to brain

Lightness	M+L	
Hue1	M-L	”redness”
Hue2	S – (M+L)	”blueness”



Human opsins

Channels to brain

Lightness	M+L	
Hue1	M-L	”redness”
Hue2	S – (M+L)	”blueness”

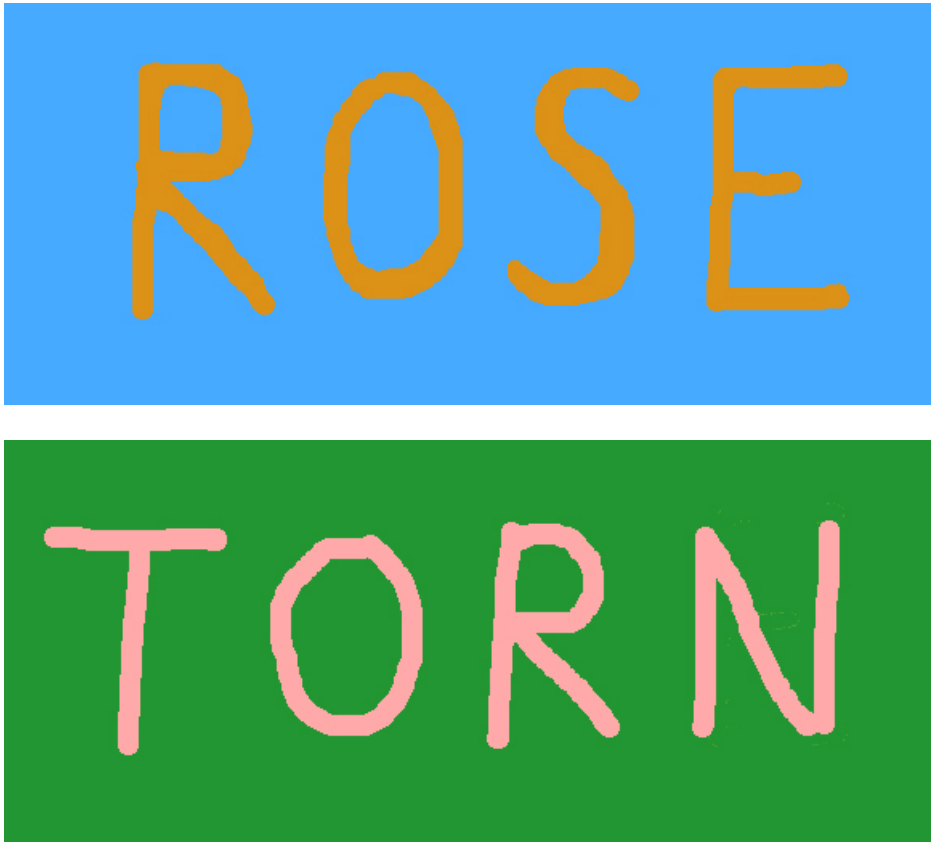
Lightness for shape, distance, movement

Hues for difference detection

Colour selection

1. Use large lightness contrast – most important

Colour selection - contrast



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	max =red	0 =yellow-green	min =blue
S – (M+L)	max =blue	0 =turquoise	min =yellow-green

Colour selection - hue

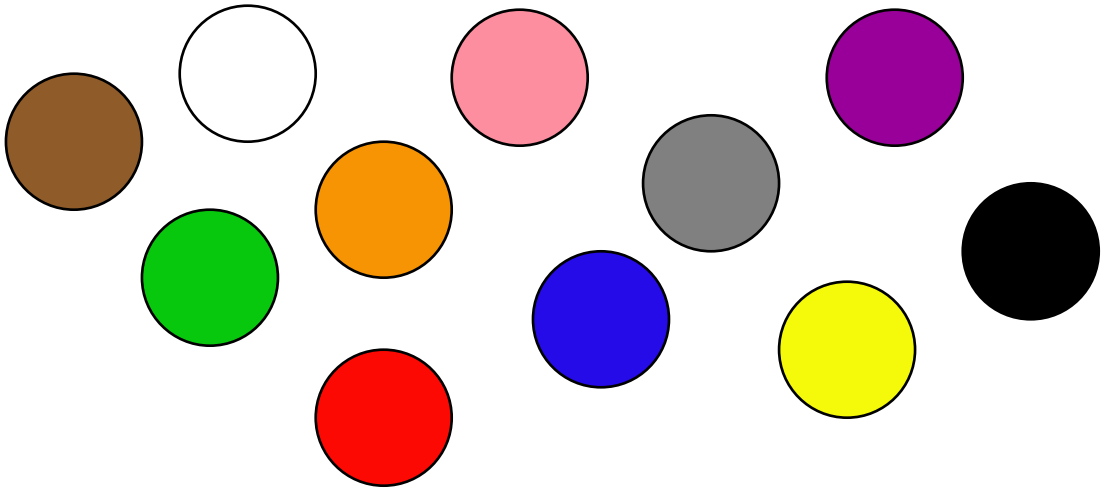
M-L max and min

S-(M+L) max and min

Do not put colours with high opposite signals from the same channel together

Colour selection – basic colours

Humans can name about 10 basic colours – 11 in English

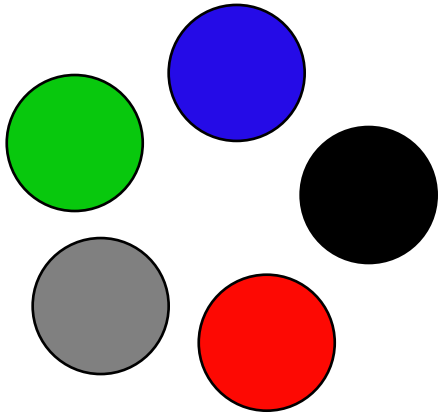


Red . Green . Blue . Yellow . Pink . Violet . Orange . Brown . White . Grey . Black

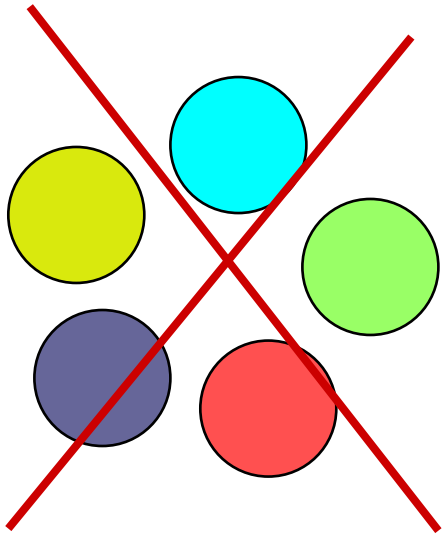
Colour selection

1. Use large lightness contrast – most important
2. Do not overstress the hue channels
3. Use basic colours

Colour selection – basic colours



Use familiar basic colours – they are easier to remember between text and figure.

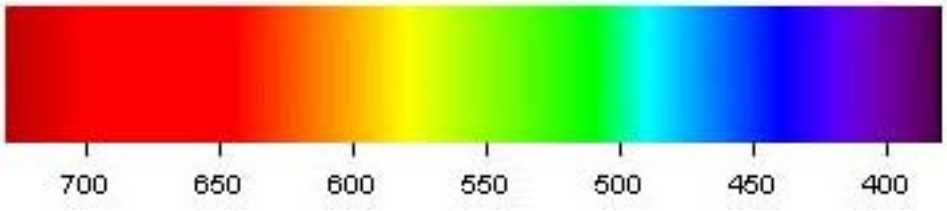


Colour “blindness”

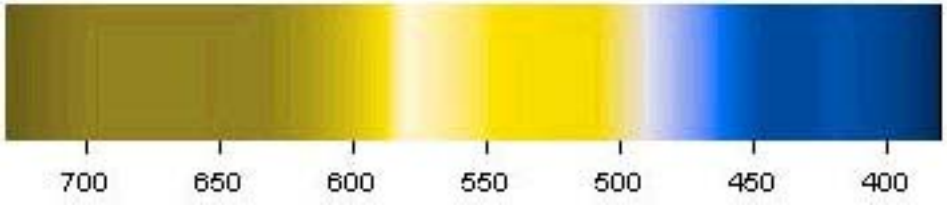
Red-green blindness about 8% men and 7‰ women (and all cats and dogs).

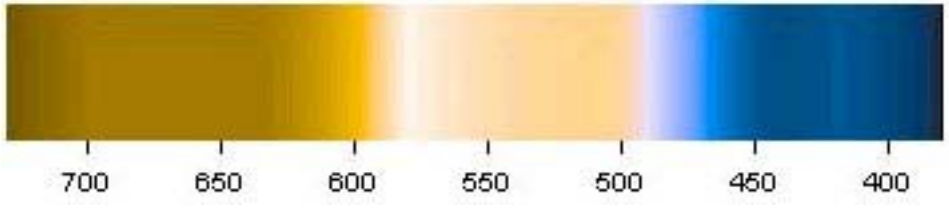
Blue-yellow blindness about 1‰ both men and women.

Colour selection – colour blindness

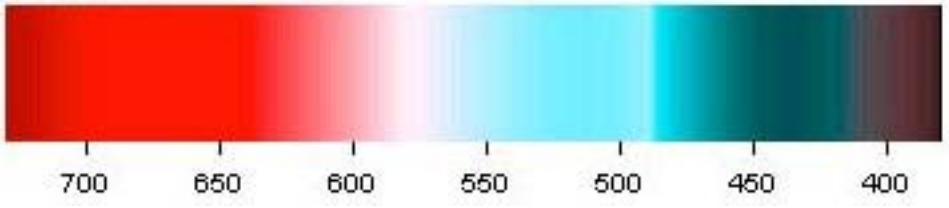


Normal colour vision





Red-green blindnesses
(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

⇒

about **4.5** million colours
are theoretically different

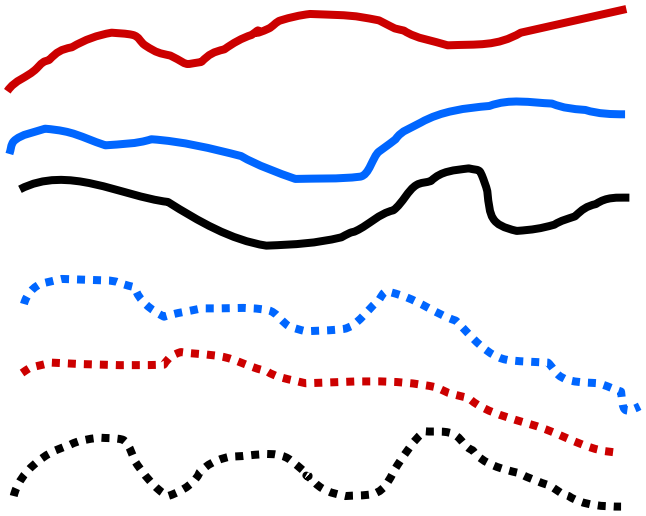
Colour selection – number of colours

Stressed humans can distinguish **3-4** colours

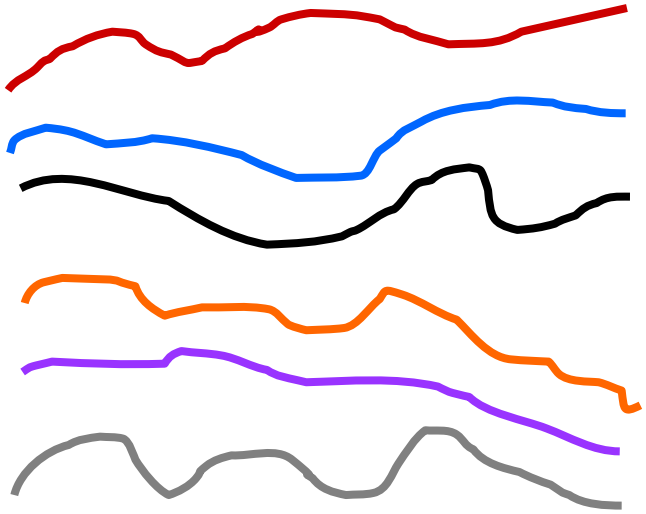
Colour selection

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

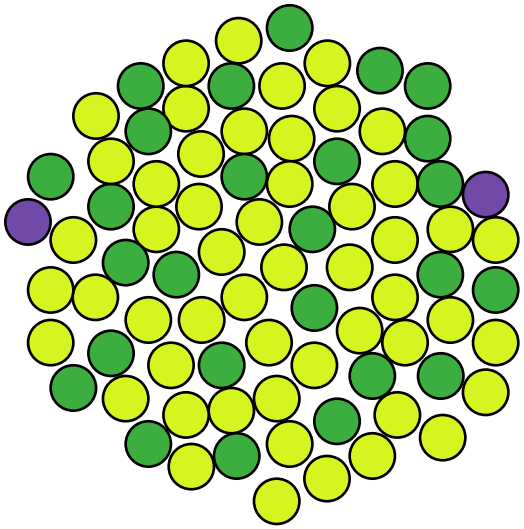


3 colours and two textures are better…



…than 6 colours and one texture.

Colour selection – blue



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

This text is hard to read: α β γ δ π ξ ο ι

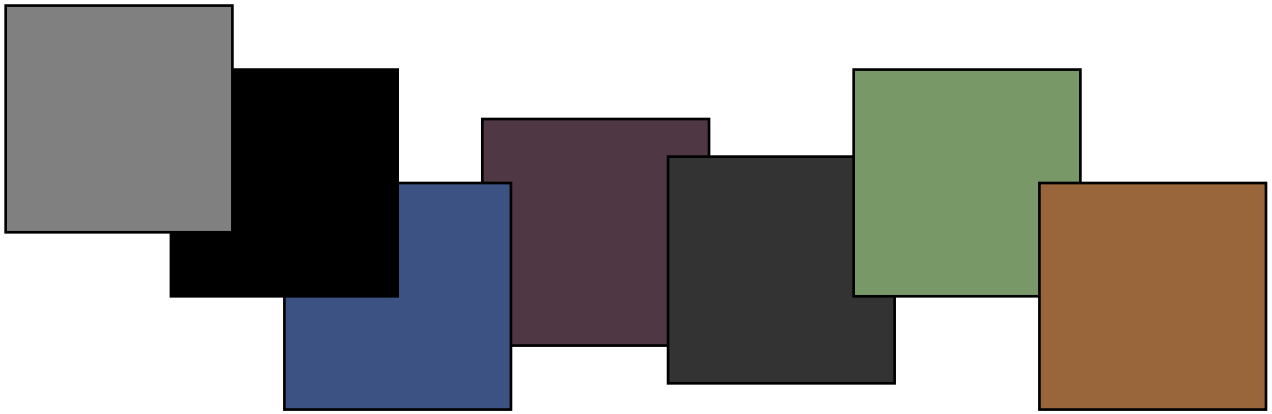
…compared to this text: α β γ δ π ξ ο ι

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

Colour selection

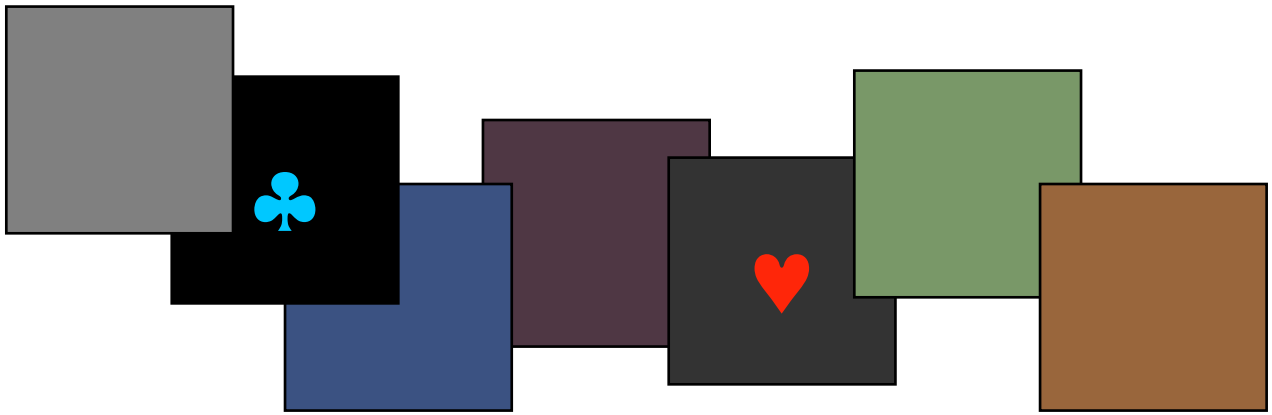


Low-saturation colours
are good for large areas.

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
8. Use bright colours only for small spot signals

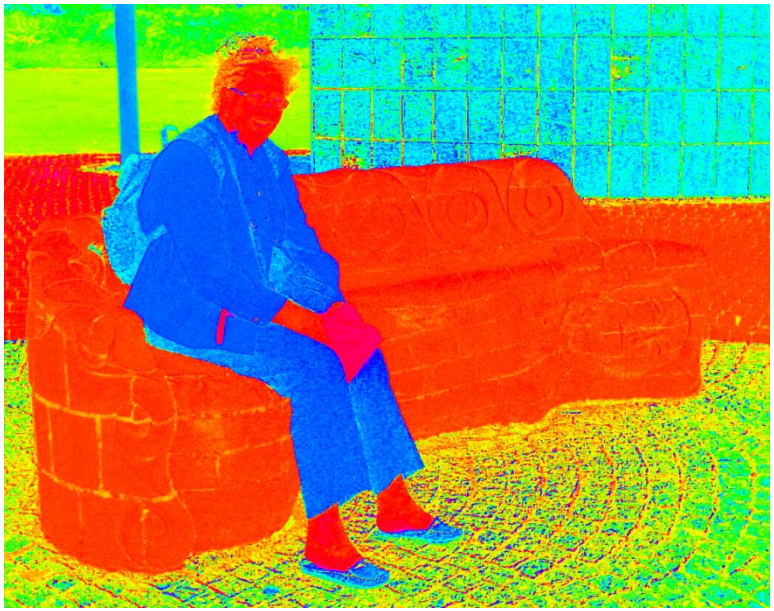
Colour selection



Small, bright attention-getters are efficient.

Colour selection – false colours

Lightness image



Hue image

Colour selection

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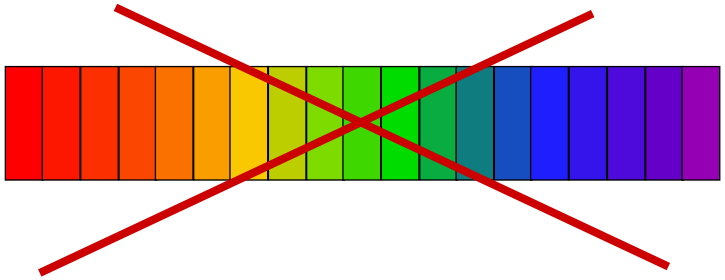
2. Do not overstress the hue channels
3. Use basic colours
4. Think of the colour-blind
5. Do not use more than 3-4 colours
6. Do not use blue for fine details
7. Use mostly muted colours
8. Use bright colours only for small spot signals
9. Beware of false colouring

Colour selection – false colours

Grey-scale

Red-blue scale



Rainbow scale

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.

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

Colour selection - compression

No compression

JPG-compression

Colour selection - compression

JPG-compression favours lightness over colour ⇒

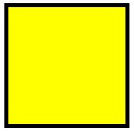
Strong JPG-compression destroys colours!

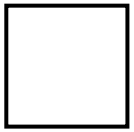
Colour selection – 10 points

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
9. Beware of false colouring
10. Beware of compression

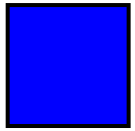
Heraldic tinctures

Metals


Or

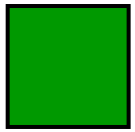

Argent

Colours


Azure


Gules


Sable


Vert

Heraldic tinctures

Uppsala

Uppland

von Linné

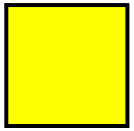
Hedemora

Ljusdal

Söderköping

Heraldic tinctures

Metals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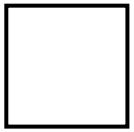
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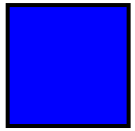
Colours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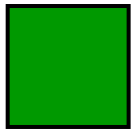
Vert

Rules:

Metal on metal – NO*

Metal on colour – YES

Colour on metal – YES

Colour on colour – NO

$\Rightarrow$

Follows ALL the rules!

*Except Kingdom of Jerusalem and the pope

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.

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.

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

The End!