Making Figures Accessible

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This guide seeks to help all those involved with creating and publishing content to improve the accessibility of any figures produced. Individual projects may still face constraints that mean that not all guidance can be adhered to.

For example, the space available within a print format may mean the size of the labelling cannot be as large as is recommended. As guidance, research, and understanding of accessibility develops, we also intend to update and improve this guidance.

If you have any feedback on these guidelines, or suggestions for improvements, please get in touch with us at the address below:

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Useful Links

Accessible Fonts
- FS Me Regular / FontSmith website
- Source Sans Pro Regular / Google Fonts
- Open Sans Regular / Google Fonts

Colour Blindness Simulator
- Coblis

Colour Contrast Checkers
- WebAIM Colour Contrast Checker
- Snook checker

Web Content Accessibility Guidelines (WCAG)
- Introduction and Overview
- Use of Colour
- Minimum Colour Contrast Requirements
Does making colours accessible just mean avoiding red and green?

No—there are many forms of colour blindness, meaning that colour can be perceived in many different ways.

For example, a typical colour palette is shown below, and the images on the right demonstrate how this palette may be perceived by readers with various forms of colour blindness.

If a manuscript refers to the ‘red line’ or ‘red area’ in a figure, a reader with protanopia would not be able to perceive which line/area is being referred to. Therefore, in order to be accessible:

- meaning should not be communicated only through colour – avoid referring to colour in the manuscript as the only cue to meaning
- use other cues such as text labels, varying pattern and/or shapes etc
What is colour contrast?

Contrasting colours are colours that differ from one another. Levels of contrast vary from high to low, depending on their position on the colour wheel. For example, colours that are directly opposite one another on the colour wheel have the highest contrast possible, while colours next to one another have a low contrast.

Partial sight, aging, and congenital colour deficits all produce changes in perception that reduce the visual effectiveness of certain colour combinations. Two colours that contrast sharply to someone with normal vision may be far less distinguishable to someone with a visual disorder. It is important to appreciate that it is the contrast of colours against another that makes them more or less discernible rather than the individual colours themselves.

Here are three rules for making effective colour choices:

- Exaggerate lightness differences between foreground and background colours
- Avoid contrasting hues from adjacent parts of the circle
- Use a colour contrast checker to validate the success of the colour combinations within the Minimum (AA) WCAG Contrast and Colour Requirements
1. Exaggerate lightness differences between foreground and background colours

Don’t assume that the lightness you perceive will be the same as the lightness perceived by people with colour deficits. If you lighten your light colours and darken your dark colours, you will increase the visual accessibility of your design.

2. Avoid using colours of similar lightness adjacent to one another, even if they differ in saturation or hue

Hue enables us to identify basic colours, such as blue, green, yellow, red and purple. People with normal colour vision report that hues follow a natural sequence based on their similarity to one another. With most colour deficits, the ability to discriminate between colours on the basis of hue is diminished, and it is difficult to discriminate between colours of similar hue.
Understanding the WCAG “Contrast Ratio”

OUP recommends that colour used in our publications meet the WCAG minimum (AA) contrast ratios. In WCAG, contrast is a measure of the difference in perceived “luminance” or brightness between two colours. This brightness difference is expressed as a ratio ranging from 1:1 (e.g., white on white) to 21:1 (e.g., black on a white). There are different requirements for non-text and text contrast.

**WCAG 2.1 SUCCESS CRITERION 1.4.11 NON-TEXT CONTRAST**

The visual presentation of Graphical (non-text) Objects should have a contrast ratio of at least 3:1 against adjacent colour(s). If a graphic is needed to understand the content then it should be perceivable by people with low vision or other impairments without the need for contrast-enhancing assistive technology.

**WCAG 2.1 SUCCESS CRITERION 1.4.11 TEXT CONTRAST**

The presentation of text should have a contrast ratio of at least 4.5:1 for normal text and 3:1 for large text. Large text is defined as 14 point and bold or larger, or 18 point regular or larger. To give a frame of reference, on a white background:

- Pure red (#FF0000) has a ratio of 4:1: **SAMPLE TEXT AT 14 PT**
- Pure green (#00FF00) has a very low ratio of 1.4:1: **SAMPLE TEXT AT 14 PT**
- Pure blue (#000FF) has a contrast ratio of 8.6:1: **SAMPLE TEXT AT 14 PT**

In Example 1, only the blue on white passes the WCAG requirements for colour contrast. The other colours do not pass both with text or non-text objects. See below for one way this could be fixed.

In Example 2, variations in layout are added (a dark rule around light non-text background colours) as well as alternating black and white text as needed. It is okay to treat labels in different ways to ensure they meet contrast requirements.

To create a uniform look, the gray border is applied to all slices, even though it isn't required on Slices C and D.
Colour Contrast

Using an online Contrast Checker

There are many resources online that can help you to validate the success of colour combinations, such as WebAim.org (See also the Useful Links section of this document). Enter a foreground and background colour in RGB hexadecimal format (e.g., #F7DA39). The Lightness slider can be used to adjust the selected colour.

Based on the values entered, you will be told if you pass or fail a Colour Contrast check using the WCAG requirements for:

• Normal Text (4.5:1)
• Large Text (3:1)
• Graphical Objects/non-text (3:1)

In the examples, the yellow on white test has failed in all categories, as the contrast is well below the 3:1 or 4.5:1 requirements. This combination should not be used for either text or non-text objects.

To the right of that example, the lightness in the yellow has been decreased, so it appears more as a dark gold. The gold on white passes in all categories, as the contrast is above 3:1 and 4.5:1. This combination would work well for both text or non-text objects.
1. Example colours tested for non-text contrast

The colour boxes to the right are colours tested for non-text contrast (i.e. graphical objects) against white to AA Accessibility standard.

- Avoid using colour as the only cue to convey meaning, and do not refer to the object by colour
- Colours should be strong and contrast well with surrounding areas, and each other when being used to differentiate
- Where tints are used, use an outline to define the shape so that it contrasts with the surrounding background
- Do not use colour for typography unless absolutely necessary – it is best to use black text on a white background (not all colours in the figure specification may be suitable for text use – those with an * on the right accessible palettes are not)
- Yellow should also be avoided for graphical objects – it needs to be dark enough to contrast with the background, meaning it becomes more gold, like the examples on the right
Text Accessibility

What do we need to consider for text accessibility?

Font type and presentation has a significant impact on readability of people with dyslexia. Studies have shown that sans serif, roman and monospaced font types increased the reading performance of dyslexic readers. A combination of principles regarding typography, readability, legibility, and colour will have a significant effect on text accessibility. Therefore, in order to be accessible, if possible please:

- Use a font size within figures set to 12-14pt or equivalent
- Limit the use of font variations such as italic, bold, ALL CAPS or other styles that may make the content difficult to read
- Do not use underlines for items that are not links
- The use of colour should adhere to general colour accessibility principles. Ideally, place text on single colour backgrounds. Avoid background patterns or pictures and distracting surrounds.

✗ Avoid using a serif-font
✗ Using a font-size under 12pt or equivalent is not recommended
✗ Avoid font variations such as italic, bold, ALL CAPS, or other styles when possible
✗ Avoid placing text on top of a colour or pattern
Accessible Fonts

OUP recommends using one of the following approved fonts for your charts and figures. Please find licensing information in the Useful Links section of this document.

✓ FS Me Regular: designed specifically to improve legibility for people with learning disabilities. Every letter of FS Me was tested for its appeal and readability with a range of learning disability groups across the UK.

✓ Source Sans Pro Regular: A Google Font. These fonts are licensed under the Open Font License. You can use them freely in your products & projects - print or digital, commercial or otherwise.

✓ Open Sans Regular: A Google Font. These fonts are licensed under the Apache License, Version 2.0. You can use them freely in your products & projects - print or digital, commercial or otherwise.

✓ Uses FS Me Regular
✓ Labels are set at 12.5pt font size
✓ Does not have any styling outside of font type and size
✓ Type is placed on a background that meets colour contrast guidelines, and/or is placed in a white box.
What do we need to consider for line graphs?

A simple line graph is shown below, and the images on the right demonstrate how this graph may be perceived by readers with various forms of colour blindness.

In most cases the reader may be able to match the colour in the legend to the colour of the plot line, even if not perceiving the colour as intended. But, there are instances where the colour isn't easily discernible, e.g. deuteranopia. Therefore, in order to be accessible, the plot lines on a line graph need to either:

- have a label next to the plot line (with or without leader line, as necessary)
- use different stroke styles (e.g. solid, dashed, dotted)
- use different symbols for data points

The next pages show how these techniques ensure the content can be understood by a reader with any form of colour blindness.
Option 1: Labels next to the plot lines

Here the line graph has a label next to each plot line, which ensures the colour isn’t necessary to identify which line is which – the colour is supplementary. A legend isn’t required.

Where graphs are more complex, and/or placing a label nearby is difficult, a leader line could be used for clarity:
Option 2: Different stroke styles for plot lines

These plot lines each have a different stroke/line style, which ensures the plot line can be matched to the legend without relying on colour. Colour is a supplementary aid.
Option 3: Different symbols for data points on plot lines

The plot lines each have a different symbol to identify data points, which also aids recognition of which line is which without relying on colour. Colour is a supplementary aid.

N.B. Where graphs are very complex, adding data points may make the graph overcrowded.
Cheat sheet

✗ Do not solely rely on colour to identify the plot line from the legend

The plot lines on a line graph need to either:
✓ have a label next to the plot line (with or without leader line, as necessary)
✓ use different stroke styles (e.g. solid, dashed, dotted)
✓ use different symbols for data points
Other elements to consider

1. Highlighting areas

Any areas to be highlighted need to be easily identifiable, by having sufficient colour contrast and outline as necessary, and/or pattern. A few examples are shown:

- The shaded areas do not contrast sufficiently
- add an outline/dividing rule to the shading
- use a combination of shading, outline, and pattern
- use pattern

2. Complex graphs/multiple lines

Where a graph is complex, containing multiple plot lines overlaid, it may become more confusing to use stroke styles for each plot line, and data points and adjacent labels not practical. Therefore you may need to consider other ways to show multiple plots so that they are not overlaid, if detail is required.

- relies solely on colour, without sufficient colour contrast of plot lines to background
- use different stroke styles, but may be confusing at small sizes
- consider an alternative: reducing the number of plots on one graph, and split into a group of graphs if detail is required
Grouped Bar Graphs

What do we need to consider for grouped bar graphs?

Readers with various forms of vision impairment may have difficulty telling areas of the grouped bar graph apart.

The accessibility of bar graphs can be improved by:

• labelling individual bars so the reader does not need to rely on perceiving colours in the legend
• using a colour palette with high contrast between shades (as opposed to using colours that are different hues but tonally similar)
• using patterns or textures with, or instead of, colour
• ensuring there is sufficient contrast between the bars, and between the bars and the background

The next pages show how these techniques ensure the content can be understood by a reader with any form of colour blindness.
Grouped Bar Graphs

Option 1: Labels for each bar

Where possible, the bars should be labelled, so that a legend is not required to understand what the different bars represent.
Option 2: Use a colour palette with high contrast

Increasing the contrast between the different colours used in the graph (e.g. using a dark, medium, and light shade as below), makes the different bars easier for most people to perceive. This option should be used in combination with another, such as labelling the bars, so that colour is not solely relied on to convey meaning.

Where any colours used do not have sufficient contrast with the background (e.g. the pale purple and the white background) a border in a shade with sufficient contrast should be used.

The grey border around the pale purple ensures the required contrast ratio between the bar and background is met.
Option 3: Use patterns and textures

In this example, the bars are filled with different patterns or textures. This can be used in combination with colour, or simply in black and white. This option may be particularly useful where adding labels is not possible and a legend is required.

![Grouped Bar Graphs](image)

**ANOMALOUS TRICHROMACY**
- Protanomaly (red weak)
- Deuteranomaly (green weak)
- Tritanomaly (blue weak)

**DICROMATIC VIEW**
- Protagonia (red blind)
- Deuteranopia (green blind)
- Tritanopsia (blue blind)

**MONOCHROMATIC VIEW**
- Achromatopsia (monochromacy)
Cheat sheet

- Do not solely rely on colour to identify the meaning of the bars from the legend
- Avoid bars touching—this makes it harder to differentiate when low contrast colours are used

The accessibility of grouped bar graphs can be improved by:

- having a label next to the relevant bar
- adding space or a border between each bar
- using textures/patterns for each bar
- using a colour palette with high tonal contrast
- using a border around each bar to ensure there is sufficient tonal contrast between the bar and the background (e.g. a light colour on a light background)
What do we need to consider for scatter plots?

A simple scatter plot is shown below, and the images on the right demonstrate how this graph may be perceived by readers with various forms of colour blindness.

In most cases the reader may be able to see the correlation between the x and y axes, even if not perceiving the colour as intended. But, there are instances where the relationship isn’t easily discernible, e.g. overlapping points. Therefore, in order to be accessible, the scatter graph should either:

- add a trend line where appropriate
- use transparency and/or a border to data points to prevent clustering
- introduce a categorical third value using shapes

The next pages show how these techniques ensure the content can be understood by a reader with any form of colour blindness.
Option 1: Add a trend line where appropriate

Here the line graph has a trend line. A trend line is a straight line that best represents the points on a scatterplot that is used to show the pattern of the data. This line may show a positive trend or a negative trend, and if there are any unusual points that are affecting the computation of the trend.
Option 2: Use transparency and/or a border on data points

Here the scatter plot has both transparency and a border applied to each data point—additional signals to differentiate between overlapping or clustered points.

<table>
<thead>
<tr>
<th>ANOMALOUS TRICHROMACY</th>
<th>DICHRAMATIC VIEW</th>
<th>MONOCHROMATIC VIEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protanomaly (red weak)</td>
<td>Protagopia (red blind)</td>
<td>Achromatopsia (monochromacy)</td>
</tr>
<tr>
<td>Deuteranomaly (green weak)</td>
<td>Deuteranopia (green blind)</td>
<td>Blue cone monochromacy</td>
</tr>
<tr>
<td>Tritanomaly (blue weak)</td>
<td>Tritanopia (blue blind)</td>
<td></td>
</tr>
</tbody>
</table>
Option 3: Introduce a categorical third value using shapes

Here the scatter plot has transparency and a border applied to each data point, as well as the introduction of a new data point shape. This acts as additional signal to differentiate between a third category.
Cheat sheet

✗ Do not solely rely on colour to identify the relationship between the x and y axes

The data points on a scatter plot need to either:

✓ use a trend line where appropriate
✓ use transparency and/or a border to data points to prevent clustering
✓ introduce a categorical third value using shapes
What do we need to consider for pie charts?

To understand a pie chart you have to discern each slice of the pie chart from the others. A simple pie chart is shown below, and the images on the right demonstrate how this graph may be perceived by readers with various forms of colour blindness.

In many cases the reader may be able to see the correlation between the parts of the pie chart. But, there are instances where the relationship isn't easily discernible, e.g. small "slices", or colours that are not perceived as intended. Therefore, in order to be accessible, the pie chart should either:

• add divider lines (and label the parts/slices)
• use patterns instead of just colour
• use a table instead of a pie chart, if differences are marginal

The next pages show how these techniques ensure the content can be understood by a reader with any form of colour blindness.
Pie Charts

Option 1: Add divider lines, and label the parts/slices

Here the pie chart has contrast divider lines, to separate any touching colours, as the colours are used to differentiate between categories. Additionally, both the category name and value are included within or near the “slice” or category to indicate the differences in data. A legend is not required.

N.B. Ensure there is sufficient colour contrast between the background, the slices, and the labels. In order to contrast on a white background, the non-text items (the slices) should have a contrast ratio of at least 3:1. Text should have a contrast ratio of 4.5:1. Under these circumstances, it is unlikely black text can sit directly on the slices. In the example above, the labels are encased in a white box, or if space does not allow, using a leader line.
Option 2:
Use patterns instead of just colour

Here the pie chart uses patterns to differentiate between various groups of data, instead of using colour. Patterns and texture are well-established alternatives to colour coding areas. A legend could be used instead of data labels, if the chart is simple, but the patterns in the legend would need to be recognizable.

N.B. Patterns could pose a scalability challenge. When patterns are used, the sections should be outlined in a 1px stroke to ensure the patterns are recognizable.
Pie Charts

Option 3: Use a table instead of a pie chart, if differences are marginal

Here the pie chart shows several values with marginal difference in value. Even if the previous options were applied (divider lines, data labels, and patterns), it would be difficult to read, especially if the categories have long titles. In some cases, presenting raw numbers via a table will be easier for readers to comprehend.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category A</td>
<td>1.5</td>
</tr>
<tr>
<td>Category B</td>
<td>1.5</td>
</tr>
<tr>
<td>Category C</td>
<td>2.0</td>
</tr>
<tr>
<td>Category D</td>
<td>2.5</td>
</tr>
<tr>
<td>Category E</td>
<td>2.5</td>
</tr>
<tr>
<td>Category F</td>
<td>2.5</td>
</tr>
<tr>
<td>Category G</td>
<td>2.75</td>
</tr>
<tr>
<td>Category H</td>
<td>3.0</td>
</tr>
<tr>
<td>Category I</td>
<td>3.25</td>
</tr>
<tr>
<td>Category J</td>
<td>3.50</td>
</tr>
<tr>
<td>Category K</td>
<td>5.00</td>
</tr>
<tr>
<td>Category L</td>
<td>10.00</td>
</tr>
<tr>
<td>Category M</td>
<td>25.00</td>
</tr>
<tr>
<td>Category N</td>
<td>35.00</td>
</tr>
</tbody>
</table>
Cheat sheet

The pie chart needs to either:

✓ use divider lines (and label the parts/slices)
✓ use patterns instead of only solid colour
✓ use a table instead of a pie chart, if differences in data values are marginal
Diagrams

What do we need to consider for diagrams and figurative diagrams?

In both cases, it is important that:

- meaning should not be communicated only through colour – if items need to be grouped, consider other ways of achieving this, such as layout/headings
- text labels and leader lines refer to areas of the diagram as necessary, and labelling is clear so that it contrasts sufficiently with any background – avoid placing labels across parts/edges of the diagram

The next pages show how these techniques can be applied to improve the accessibility of diagrams.
NOT ACCESSIBLE

✗ colours don't contrast sufficiently and labelling is unclear—it is difficult to tell what part of the diagram all the labels are referring to and the legibility of the text is impaired because it overlaps with the illustration

✓ add outlines to define shapes and move labels so they are clear

ACCESSIBLE

✓ add outlines to define shapes and increase colour contrast

✗ colours don't contrast sufficiently
**Diagrams**

- **NOT ACCESSIBLE**
  - ✗ colour is used to link content to a label
  - ✗ colours don't contrast sufficiently with each other or the background

- **ACCESSIBLE**
  - ✓ use varying stroke styles
  - ✓ either increase the colour contrast, or add outlines to define the shapes
Diagrams

**NOT ACCESSIBLE**

- **Left lung**
- **Right lung**

- **Trachea**
- **Primary bronchi**
- **Secondary bronchi**
- **Tertiary bronchi**
- **Smaller bronchi**

- Colour is used to link the label to areas of the diagram

**ACCESSIBLE**

- **Left lung**
- **Right lung**

- **Trachea**
- **Primary bronchi**
- **Secondary bronchi**
- **Tertiary bronchi**
- **Smaller bronchi**

- Use an alternative layout/labelling

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Random text.
Diagrams

KEY
Brachial plexus
Lumbar plexus
Sacral plexus

Axillary
Intercostobrachial
Medial cutaneous
Musculocutaneous
Radial
Posterior cutaneous
Superficial branch
Median
Ulnar

Ilioinguinal
Genitofemoral
Lateral cutaneous
Femoral
Lateral cutaneous nerve of calf
Superficial and deep peroneal
Sural
Medial plantar

Brachial plexus
Posterior cutaneous
Superficial branch
Lumbar plexus
Lateral cutaneous
Femoral
Anterior cutaneous rami
Saphenous
Sacral plexus
Sciatic
Superficial and deep peroneal
Sural
Medial plantar

✗ colour is used to group labels
✓ colour is used to group labels with headings

NOT ACCESSIBLE
✓ ACCESSIBLE
Cheat sheet

✗ Avoid using colours that do not meet contrast guidelines

✗ Avoid relying on colour solely to link content to a

✗ Avoid using colour to link the label to areas of the

 ✓ using colours that give greater contrast and add outlines to define shapes

 ✓ using varying stroke styles

 ✓ using an alternative layout such as grouping or labels instead of relying on colour to link the content to areas of the diagram