Seeing text

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You cannot read unless you can see text, but seeing text is more complicated than it appears.

When you read, your eyes seem to advance smoothly across the page, but in fact they are moving in a series of rapid jerks, usually alighting about one third of the distance along each of the longer words in turn. Immediately after each jerk, your brain moves the eyes slowly to re-align the gaze of the two eyes. The alignment takes time, and is no greater than that just sufficient to see the word clearly through both eyes. Some words such as *mum* require a more precise alignment than others such as *dad*, probably because the regular stripes of the letter strokes can be confused, each stroke with its neighbour. As a result, words with regular stripes take longer to read, even by fluent readers. For similar reasons, striped fonts such as Times take longer to read than other less striped fonts, such as Verdana.

The requirement for precise alignment of the eyes is reduced when the font is large, as is the case when children begin to read. As their reading ability improves, the letters they are required to read get smaller, but they get small too early in life. Children aged 6-9 read more quickly and comprehend more rapidly with text of a size designed for younger children. This is of consequence when measuring reading age. Most reading tests use text that decreases in size with increasing reading age. When this is not the case and the text remains at its original size throughout the test, the average reading age it measures can improve by more than 4 months, even though the children's ability is unchanged.

There are more words on the page as reading age increases and the text gets smaller. Unless the words are so familiar that they can easily be identified and provide landmarks, it becomes ever more difficult for children to find their way around the clutter of meaningless shapes. As a result, words and letters can get transposed. Increasing the spacing between lines and words can help. Nowadays this can be done using electronic text.

Children with reading difficulty are disproportionately affected by the size and spacing of letters. They may benefit from a non-striped font such as Tahoma or Verdana, rather than the more commonly used Times and Sassoon. They will usually benefit from extra spacing between the lines. If the software permits, try increasing the separation not only between lines but also between letters and words. Then ask your child to judge the change in clarity.

Text is uncomfortable to see when strongly lit partly because it has a high contrast. Unfortunately, classrooms are usually over lit. The lights are generally left on continuously, even when they are not needed. Sometimes the light from the windows cannot be controlled because the blinds are broken. Often the lights in the darker parts of the classroom away from the windows cannot be turned on separately from the remainder. The light level can be measured using a smart phone light meter 'app', or by means of a film camera. If a photograph of a sheet of white paper on your pupil's desk would require 1/30th second or less at f5.6 with a film ISO of 100 (i.e. the exposure value is 10 or above) then the light level is too bright and text will be uncomfortable to look at.

80% of classrooms are still lit by old fashioned fluorescent lighting. The lamps flicker when they come on. They continue to flicker all the time they are lit, although the flicker has a frequency of 100 flashes per second and is too rapid to be seen. This invisible flicker has been shown to disturb the control of eye movements and interfere with vision, causing headaches. Newer fluorescent lighting comes on immediately because it is controlled by electronic high frequency ballast and it does not flicker 100 times per second. It is cheaper to run and so pays for the extra cost of its installation in about two years. When classrooms are refitted, it is important that schools choose fluorescent lighting with high frequency electronic ballast, not only for economic reasons but also for the sake of the health of children and staff.

With most modern interactive white boards, the projector is mounted from an arm at the top of the board. In older systems, however, the board is mounted vertically on a wall and the projector on the ceiling. The projector beam then reflects from the shiny surface of the board directly into children's eyes, appearing as a glare spot that interferes with the image presented on the board. When a whiteboard is used instead of an interactive board, the surface is shinier and the glare spot can be dangerously bright. The spot can usually be removed (1) by angling the board away from the wall at the top and by increasing the height of the projector; (2) by using bright text on a dark background; (3) by projecting the image onto a paper flipchart instead of onto a board with a shiny surface; pens can then be used with the flip chart to annotate the projected image.

Coloured filters placed upon the page (coloured overlays) can help some children to read. The colour has to be selected individually by each child from a large range of sufficiently different colours – at least nine[4]. Systems of coloured overlays with fewer colours do not help reading because the palette of colours is then too small to obtain a shade sufficiently close to the individual's optimum. The optimum varies considerably from one individual to another. Yellow or blue are not the most commonly chosen colours or even the most effective[5]. Children who choose the same colour consistently are more likely to benefit from the overlay. The benefit can be measured by administering the Wilkins Rate of Reading Test. The test consists of four paragraphs of randomly ordered common words. Each passage is read aloud for one minute. The first passage is read with the overlay, the second without the overlay, the third again without, and the fourth once more with the

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4 The Intuitive Overlays (ioo sales), the Cerium overlays (Cerium Visual Technologies) and the full set of Crossbow Overlays (Crossbow Education) provide a sufficient range of colours.

5 cf Stein J. (In Visual Aspects of Dyslexia; Eds Stein J and Kapoula Z: Oxford, 2012; p 182).

overlay. Individuals who reliably read the test paragraphs more quickly with the overlay tend to be those who use overlays of their own volition in the long term. The test is therefore useful in providing a rapid measure that predicts benefit. When there is little increase in speed, there is generally little benefit, at least for reading[6]. Because the test passages are meaningless, the words cannot be guessed from context. The speed of reading is therefore limited mainly by the ability to see the words. This limitation is less pronounced when conventional meaningful prose is read. Here reading speed is influenced by comprehension of the text and the consequent ability to predict the words from their context. The variability in predictability makes it difficult to demonstrate any increase in reading speed with the overlay when reading prose, at least in the short term. The increase is generally observed only after ten minutes' reading when the overlays prevent the slowing in reading speed that otherwise occurs with fatigue[7].

Children who use overlays should be permitted to write on every other line in their workbooks so that the spacing of their written work helps them to read what they have written. Allowing children to choose the colour of paper they find comfortable both for writing and worksheets can also be helpful. Sometimes coloured pens can help with writing. To enable a child to choose the best colour, prepare identical paragraphs of written work using pens of red, orange, lime green, sea green, turquoise, blue, purple and pink and ask the child to choose the paragraph they find clearest to read. Ask the child to be responsible for giving a pen of this colour to their teacher when using the whiteboard. For interactive white boards, experiment with text of

6 Ritchie, S. J., Sala, S. D. & McIntosh, R. D. (*Pediatrics*, 2011, 128 (4), pp. e932–e8) failed to show a benefit in reading rate with individuals selected by an Irlen examiner.

7 Tyrrell, R., Holland, K., Dennis, D. and Wilkins, A.J. (*Journal of Research in Reading*, 1995, 18(1), 10-23.) showed no increase in reading speed with overlays until after ten minutes reading prose. Henderson LM Tsogka N and Snowling MJ (*Journal of Research in Special Educational Needs*, in press) showed an effect of overlays on the Wilkins Rate of Reading Test but not when reading prose, but the prose passages consisted of only about 300 words, so no effect would have been expected.

different colours on backgrounds of different colours to find the optimum for the children in each class. Bear in mind that some colours may be difficult for children to see because of colour blindness, and it may be necessary to establish a compromise between the different requirements of several children in the class. Sometimes the compromise is simply a reduction in contrast.

Although the use of coloured filters is less controversial than it once was, the mechanisms whereby the filters sometimes have beneficial effects on reading remain poorly understood. The differences in the focussing power of the eye at different wavelengths may play a role but do not provide a sufficient explanation. Children who benefit from overlays are twice as likely to have migraine in the family as those who do not benefit. Recent neuroimaging studies in adults with migraine have shown an abnormal oxygenation of the brain when stressful visual stimuli are observed. The abnormality was removed when the appropriate filter was worn. The abnormality remained, however, if control filters of slightly different colour were worn, indicating the precision with which the therapeutic colour needs to be selected. The therapeutic colour varied considerably from one individual to another but the individually selected optimum was effective in reducing the otherwise abnormal brain oxygenation. Perhaps the abnormal oxygenation reflects the photophobia that accompanies migraine and is related to distortion of text and discomfort (visual stress).

Evolution has not prepared us for reading. Our eyes and brains developed to see the shapes that occur in the natural world. These shapes differ in size. Large shapes (those with *low spatial frequency*) are generally more contrasted than small (*high spatial frequency*), and the contrast of the shapes varies with their size according to a mathematical law. When we look at an image that does not conform to this law we find it uncomfortable, particularly if the contrast is greater at sizes (*spatial frequencies*) we can see most easily. The image formed by a page of text is unnatural. Not only does the image fail to conform to the mathematical law of nature, the contrast is greater at sizes where our sight is most sensitive. On both counts, the mathematics of uncomfortable images predicts that text is stressful.

That visual stress can be one cause of reading difficulty is evidenced by the fact that treatment with coloured filters can sometimes result in an immediate and sustained improvement in reading fluency. But reading difficulty has many causes and consequences. None is necessary or sufficient. Until recently, a lack of phonological awareness has been regarded as the principle cause. A lack of phonological awareness is undoubtedly strongly associated with reading difficulty, but perhaps this is because it can be both a cause and a consequence of such difficulty.

Although individuals with a family history of photophobia are the most likely to benefit from overlays, the avoidance of poor text design, poor lighting, and poor text presentation is likely to benefit everyone.

Points to consider

- For children aged 7 and above do you use Verdana or Tahoma in preference to Times and Sassoon?
- Do you use large text (i.e. that normally considered suitable for children 1-2 years younger)?
- Do you space text sufficiently?
- Is your classroom over lit?
- Can you control the light level adequately throughout the room? Removing lamps in bright areas of the classroom is one possible compromise.
- Is your classroom to be refurbished? If so, ensure the lighting has high-frequency ballast.
- Is your interactive whiteboard positioned to avoid the glare spot?
- If not, can you remove the glare spot in other ways?

- What paper colour and pen colour are appropriate for children who use overlays?
- How can individual differences in colour choice best be accommodated for group work?

Further reading

Stripiness of fonts

Hughes, L.E. and Wilkins, A.J. (2000). Typography in childrens reading schemes may be suboptimal: evidence from measures of reading rate. *Journal of Research in Reading*, 23(3), 314-324.

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Text size and reading comprehension

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Wilkins, A, Cleave, R, Grayson, N and Wilson, L. (2009). Typography for children may be inappropriately designed. *Journal of Research in Reading*, 32(4), 402-412.

Interactive whiteboards and classroom lighting

Winterbottom, M. and Wilkins, A.J. (2009). Lighting and discomfort in the classroom. Journal of Environmental Psychology, 29, 63-75.

Coloured overlays

Wilkins, A.J. (2003). Reading through Colour. Wiley: Chichester. ISBN 0-470-85116-3

Allen, P.M, Evans, B.J.W, Wilkins, A.J. (2010). Vision and Reading Difficulties. Ten Alps Creative: London

Smith, L. and Wilkins, A.J. (2007). How many overlay colours are necessary to increase reading speed? A comparison of two systems. Journal of Research in Reading 30, 332-34.

Other references available at **www.essex.ac.uk/psychology/overlays/publications2.htm**

Neuroimaging in migraine

Coutts, L.V. Cooper, C.E., Elwell, C.E. and Wilkins, A.J. (2012). Time course of the haemodynamic response to visual stimulation in migraine, measured using near-infrared spectroscopy. Cephalalgia , 32(8) 621–629.

Huang, J., Zong, X., Wilkins, A., Jenkins, B., Bozoki, A. and Cao, Y. (2011). fMRI evidence that precision ophthalmic tints reduce cortical hyperactivation in migraine. Cephalalgia. 31(8):925-36.

The mathematics of uncomfortable images

Fernandez, D. and Wilkins A.J. (2008). Uncomfortable images in art and nature. Perception, 37(7), 1098 1113.

Juricevic, I, Land, L, Wilkins, A.J. and Webster, M.A. (2010). Visual discomfort and natural image statistics. Perception, 39(7), 884-899.

The above articles can be downloaded as pdfs via
www.essex.ac.uk/psychology/overlays