

How big does a coloured overlay have to be?

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Abstract

Coloured overlays and coloured lenses can both increase reading speed, but when they do their colour is not necessarily the same, suggesting that the beneficial effects of a coloured filter might depend upon the area of the visual field that it colours. We investigated the effects of overlays on reading speed and varied the size of the overlay and the colour of the surround. Children who had been assessed with coloured overlays were required to read a passage of randomly ordered common words. The words were printed in black ink as a block of text positioned centrally on an A4 page of white paper in landscape orientation. The speed of reading was compared under four conditions: (1) without an overlay; (2) with an overlay of the chosen colour covering the entire page; (3) with the overlay cut so that it just covered the text but left the margin white; (4) with the overlay of the chosen colour covering the text but with the margin coloured a complementary colour, using a second overlay. The children who were using an overlay read more quickly with the overlay; those who were no longer using the overlay did not. Although the block of text covered less than half the page, the colour and nature of the margin did not affect reading speed significantly. These findings suggest that in order to be effective at improving reading speed an overlay needs to cover the text, but not necessarily the remainder of the page, which means that smaller overlays may sometimes be sufficient.

Keywords: coloured overlays, dyslexia, Meares–Irlen syndrome, reading speed, visual stress

Introduction

Certain individuals report distortions of text when they read. The distortions can often be reduced when the text is coloured by covering it with a coloured plastic overlay (Robinson and Miles, 1987; Irlen, 1991; MacLachlan *et al.*, 1993; Wilkins, 1994; Tyrrell *et al.*, 1995; Evans *et al.*, 1996a,b, 1999; Jeanes *et al.*, 1997; Lightstone *et al.*, 1999; Evans and Joseph, 2002; Kriss, 2002; Scott *et al.*, 2002). Five per cent of children in mainstream education read more than 25% faster when using an appropriately coloured overlay (Wilkins *et al.*, 2001). The mechanisms underlying this improvement in reading fluency are thought to relate to the cortical hyperexcitability with which migraine is associated (Wilkins, 2003). In brief, the colour of the overlay is

thought to redistribute cortical excitation and thereby avoid local areas of hyperexcitability. Be that as it may, the children who persist in using an overlay are those who show an improvement in reading speed with the overlay (Jeanes *et al.*, 1997). They show no corresponding reduction in reading speed with overlays of complementary colour (Jeanes *et al.*, 1997). The improvements can be measured using the Rate of Reading Test in which the individual is required to read randomly ordered common words aloud as rapidly as possible (Wilkins *et al.*, 1996). Only common words are used so that the material is familiar to poor readers. The test has the advantage that the words cannot be guessed from context and must be seen to be read. The text is small and closely spaced so as to resemble the patterns that are most likely to evoke distortions. Performance is therefore determined more by the visual aspects of reading than is typically the case when reading meaningful material. Nevertheless the test has predictive validity in the context of more natural reading tasks (Wilkins *et al.*, 2001).

The optimal colour for improving reading speed differs from one individual to another, and has to be

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selected with precision (Wilkins, 2003). The Intuitive Overlays provide a surface colour and allow for the selection of the optimal shade of colour from 30 alternatives (Wilkins, 1994). The Intuitive Colorimeter (Wilkins *et al.*, 1992; Wilkins and Sihra, 2000), which allows continuous manipulation of colour within the gamut, illuminates the entire field of view with coloured light, as do coloured lenses. For reasons that are not altogether clear, the colour selected as optimal under these conditions differs from that selected as optimal in overlays (Lightstone *et al.*, 1999). One possible contributing factor is the range of colours available (smaller in the case of overlays), and another is the colour adaptation that occurs when the entire field is coloured, as in the colorimeter. These findings suggest that, were an overlay to be increased in size until it covered the entire field, its optimal colour should change. Such considerations raise the issue as to what the optimal size of an overlay should be. Is the beneficial effect on reading speed dependent on the colour of the surround?

The colour appearance of a surface depends upon the colour of its background. If a surface that is a neutral grey in colour is surrounded by a strongly saturated colour, the grey surface will tend to take on the appearance of the colour complementary to that of this surround: the background is said to induce colour, a phenomenon known as simultaneous contrast (Beck, 1972). It is possible that mechanisms of induction of this kind play a role when overlays are used. If the overlay is small and the white margin of the page surrounds the overlay, the overlay may appear more saturated than it does when the entire page is covered by the overlay and appears a uniform colour. It is possible, at least in principle, that the difference in apparent saturation might influence the effectiveness of the overlay. When the surround has a colour complementary to that of the overlay, these effects should be maximal, although the failure of Jeanes *et al.* (1997) to show any reduction in reading speed with an overlay of colour complementary to that optimal for increasing reading speed suggests that any effects of surround colour may be slight.

Reading speed was therefore assessed using the Rate of Reading Test under four conditions: (1) with a white page; (2) with the white page completely covered by an overlay of the chosen colour; (3) with a smaller overlay of similar colour just sufficient in size to cover the text but not the surrounding margin and (4) with the small overlay covering the text as above, but with an overlay of complementary colour covering the surrounding margin.

The participants were children in schools where screening with coloured overlays had taken place in the previous school year. About 20% of the children were still using their overlays.

Methods

Study 1

Participants. All the 350 pupils aged between 7 and 11 years in a North Norfolk school were assessed using coloured overlays according to the procedures suggested by Wilkins (2003). Parents were given the option of withdrawing their children from the study. The following year, two groups of participants were selected. The first group consisted of 14 girls and seven boys, mean age 9.4, all of whom had improved their rate of reading with an overlay and who were still using an overlay at the time of the study. The second, smaller, group consisted of four girls and one boy, mean age 8.6, who had been issued with overlays and had used them for several months, but were no longer using them at the time the present study was conducted. The sampling was otherwise opportunistic, as school timetables permitted. No selection was undertaken on the basis of scholastic or optometric criteria. The data for three children were discarded for reasons described below.

Materials. An A2-sized card was covered with black velvet. The card was placed on the horizontal surface of a table in front of the child in landscape orientation. The test materials measuring 297 mm wide × 193 mm high were mounted symmetrically on the vertical midline 130 mm from the bottom edge of the card, at a comfortable reading distance for the child.

The passage of text with 15 words per line and 20 lines, 18 mm high × 90 mm wide, was positioned centrally on a page of white A4 paper (landscape orientation). The text was printed in sans serif 10 pt Ariel font single-spaced. The same 15 high frequency words appeared on each line in a different random order: 'and, cat, come, dog, for, is, look, my, not, play, see, the, to, up, you'.

Five such passages were prepared, each with a different random order. One passage was used for practice. The remaining passages were allocated at random to each of the four conditions. An overlay of the chosen colour was trimmed to cover only the text of the passage (80 × 92 mm) and none of the surrounding white margin. An A4 sized overlay was trimmed to cover the entire page, including the text and its margin. A section measuring 80 × 92 mm was removed from the centre of another A4 overlay so that this overlay could be used to colour just the surrounding margin of the text. The colour of this overlay was complementary to that of the central overlay. It was selected at random from the two Intuitive Overlays with hue angle (CIE h_{uv}) approximately 180° from that of the chosen overlay. As has been the case in previous studies, the choice of overlay colour varied from child to child. Six chose

aqua, six mint-green, three orange, three purple, two lime-green, two blue, and none chose grey.

The children were given 1 min in which to read as many words as possible without mistakes. The practice text was followed by each of the four conditions presented in random counterbalanced order.

The testing took place in a quiet room lit with daylight and fluorescent lighting typical of the classroom. Care was taken to ensure that there were no reflections of the light sources on the surface of the materials. The reading was tape recorded with the child's verbal permission. Some overlays were used with the matt surface uppermost and some with the gloss surface uppermost, as chosen by the child, the same for all overlay conditions.

Because of their age, the children were not asked to assess the apparent colour saturation of the test materials.

Results. The mean rate of reading under each of the four conditions is shown in *Table 1*. The testing was stopped with one child because sore eyes and headaches were reported. In two further children the data were omitted because of an error in the tape recording. The data from these children were excluded and did not contribute to *Table 1*. The response sheets were analysed by counting the number of words correctly read in the correct sequence, in accordance with the guidelines suggested by Wilkins (2003). A single factor within-subjects analysis of variance for the children who were still using their overlays revealed a significant difference between the four conditions ($F_{3,60} = 3.72, p = 0.016$). A subsequent Newman-Keuls test showed that the children read significantly faster with the small overlay than with no overlay at all. A single factor within-subjects analysis of variance for the three conditions in which an overlay was used found no significant differences between these conditions ($F_{2,40} = 0.85, p = 0.43$). Analyses of the improvement in reading speed with overlays

also failed to reveal any difference between these conditions.

Previous work has shown that children who do not continue using overlays fail to show an increase in reading speed with the overlay (Wilkins, 2003). In view of this finding, and also in view of the small sample size involved in the present study, it is unsurprising that the few children who were no longer using the overlay failed to show any significant difference between the four conditions ($F_{3,6} = 0.61, p = 0.62$).

In order to increase the sample size, a further 18 children were tested, omitting the *no overlay* condition to reduce the testing time.

Study 2

Participants. Two groups of children from a school of 369 pupils in the south west of Norwich took part. Again, all the children in the school had been assessed with coloured overlays the previous year. One group consisted of nine girls and three boys who were still using their overlays. A second group consisted of three girls and three boys who were no longer using their overlays. Both groups had a mean age of 9.7 years. The mean rate of reading for the three conditions is shown in *Table 2*. As before, parents were given the option of withdrawing their children from the study. Seven children chose aqua overlays, three orange, three mint-green, two purple and none chose grey.

Results. The data are summarised in *Table 2*. A single factor within-subject analysis of variance failed to reveal any significant difference in reading speed or errors between the three overlay conditions for the children who were still using their overlays ($F_{2,22} = 0.002, p = 0.99$; NB: the *no overlay* condition was not included). A similar non-significant finding was obtained for the few children who no longer used their overlays ($F_{2,10} = 0.24, p = 0.79$).

Table 1. Mean values (and standard deviations) of reading speed (words per minute) for each of the four conditions of Study 1. Data for the 21 children who were still using their overlays are shown separately from those for the five children who were not (Three children were excluded from the study and their data are not shown below)

	No overlay	A4 overlay	Small overlay	Small overlay with complementary surround
Still using ($n = 21$)	76.4 (26.6)	85.1 (24.7)	89.3 (30.2)	85.9 (25.5)
Stopped using ($n = 5$)	68.4 (32.3)	68.6 (25.4)	75.2 (27.5)	72.2 (21.0)

Table 2. Mean values (and standard deviations) of reading speed (words per minute) for each of the three conditions of Study 2. Data for the 12 children who were still using their overlay are shown separately from those for the six children who were not

	A4 overlay	Small overlay	Small overlay with complementary surround
Still using ($n = 12$)	105.9 (32.1)	105.8 (32.7)	105.7 (32.7)
Stopped using ($n = 6$)	101.8 (28.2)	101.3 (35.8)	104.5 (26.0)

Discussion

Both experiments are consistent with others in showing that children who choose to use overlays read faster with them (for review see Wilkins (2002)). The present findings extend this earlier work in that they show that the colour surrounding the overlay does not affect reading speed, at least within the range examined. It remains possible that the effects are rather different when the surround is very large and is similar in colour to the overlay, as when the entire field is coloured, for example during examination with the Intuitive Colorimeter. Under these conditions the eyes adapt to the colour much as they do to the colour of a light source, and the colour of a light source is usually discounted by mechanisms of colour constancy. These mechanisms may help to explain the difference in the colour optimal for use in overlays and that optimal when in the Intuitive Colorimeter (Lightstone *et al.*, 1999).

Jeanes *et al.* (1997) showed that an overlay of a colour complementary to that reported as optimal has little effect on reading speed. The absence of any differential effect of a complementary surround colour is consistent with this finding.

The present studies show that an overlay has its effect when it is sufficient to colour all the text. Small overlays may therefore be suitable for small books, a finding of some practical significance. Further studies will be needed to answer the question as to whether overlays that only partially cover the text are sufficient to be effective.

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