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Coloured overlays, text, and texture

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Abstract. In four studies children were asked to read aloud a passage of randomly ordered common words with and without a coloured sheet of plastic (overlay) placed upon the page. The children's rate of reading increased with the overlay, for some children more than for others. The children were also asked to undertake a test of texture segmentation in which targets consisting of a structured texture had to be distinguished from within a random background texture. The texture segmentation was improved when the overlay was used, again for some children more than for others. The improvement in texture segmentation was, in general, correlated with the improvement in rate of reading. Slower readers were generally poorer at texture segmentation. The implications for reading, for texture segmentation, and for clinical tests of vision are discussed.

1 Introduction

Certain individuals read more fluently when the text they are reading is covered by a sheet of coloured plastic (an overlay; Meares 1980; Irlen 1991; Tyrrell et al 1995). The beneficial colour varies from one individual to another (Jeanes et al 1997). The colour has a benefit expressed both as an increase in reading fluency (Tyrrell et al 1995; Wilkins et al 1996; Jeanes et al 1997) and as a reduction in symptoms of asthenopia (visual fatigue). The reduction in symptoms has been demonstrated under double-masked, placebo-controlled conditions (Wilkins et al 1994) and under conditions in which brightness and contrast are controlled (Wilkins et al 1992). The colour can be provided by overlays or by tinted spectacle lenses. When overlays are used, the colour is a surface colour; when lenses are used the colour has an effect similar to that of a coloured light source. The optimal chromaticity depends upon how the colour is provided, whether as a surface or as a source (Lightstone et al 1999). The above studies show that there are individual differences with respect to the effects of colour and that these cannot simply be attributed to the covariation of brightness contrast. In these respects they differ from previous reports of the effects of colour on reading fluency (Tinker 1963, pages 128 – 152).

Overlays have been designed that sample chromaticity systematically, comprehensively, and efficiently (Wilkins 1994). Having chosen an appropriate colour (provided by one overlay or two superimposed), about 20% of unselected normal schoolchildren aged between 7 and 11 years used the colour without prompting for more than 3 months, reporting reduced headaches. The children read more rapidly with their overlay than without, both before and after experience of its use (Jeanes et al 1997). In the present study we show that (i) the increase in reading fluency is not due to motivation (exhortation and placebo overlays are without effect); (ii) the increase is colour specific (grey overlays and those with a colour reported as nonbeneficial do not improve reading speed); (iii) the improvement in reading may be related to the ability to segregate visual texture; and (iv) both reading fluency and visual texture segregation improve when an overlay is used.

We devised the test shown in figure 1 to measure the ability to segregate visual texture. The observer was required to recognise the orientation of an arrowhead (upwards, downwards, left, or right).

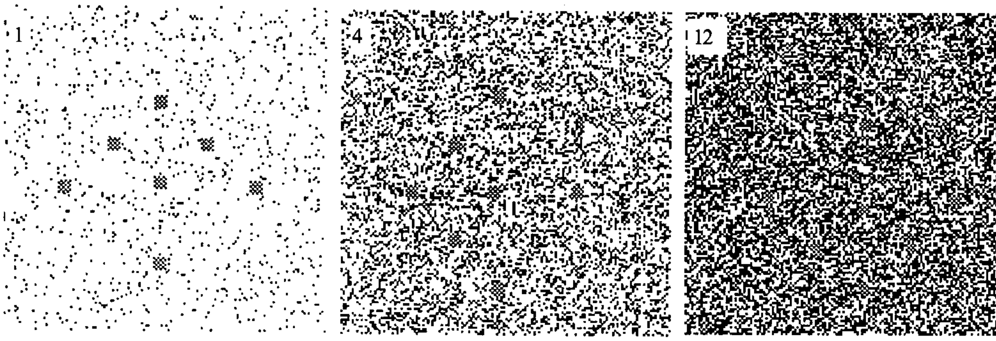

Figure 1. Examples of items from the Arrows Test of texture segregation. The test involves the search of an array of randomly arranged dots to find patches of checks. The patches are configured as an arrowhead, and the task is to identify the direction in which the arrow is pointing. The test comprises twelve panels similar to those here, but 170% larger, progressively increasing in difficulty by virtue of an increase in background dot density (maximum 50%).

2 General methods

2.1 *Subjects*

The subjects who took part in the first three experiments were children who had been referred by their school to the Norfolk Sensory Support Service. The service exists to help children with sensory difficulties, particularly those who are partially sighted or have a hearing impairment. However, for the last 4 years the Service has also taken referrals from teachers who wish to have their children assessed with coloured overlays. The children are usually making poor progress in school. The referrals are heterogenous, and for this reason unselected children from normal schools were recruited for experiment 4.

2.2 *Stimulus materials*

2.2.1 *Coloured overlays.* The overlays used have been described previously (Wilkins 1994).[(1)] When placed over a page of white paper the overlays had a reflectance that varied little with the angles of incident and reflected light (Wilkins 1994, figure 3), provided that specular reflection was avoided. They had chromaticities disposed evenly around the circumference of a circle in the CIE 1976 UCS diagram, centred on white. The hue angle, h_{uv}, between neighbours averaged 40° with a standard deviation of 7.7°; the saturation, s_{uv}, averaged 0.52 with a standard deviation of 0.19. The photopic reflectance (when the overlay was placed upon a halon standard) averaged 65% (standard deviation 13%). The overlays provided nine colours (and a grey, reflectance 47%) when used singly. They were also used in pairs, one on top of another. The pairs were either of the same colour or of neighbouring chromaticity and provided a further nineteen colours having greater saturation (s_{uv} average 1.1, standard deviation 0.13) with a hue angle between neighbours averaging 20°, standard deviation 4.8°. The overlays therefore sampled colours systematically and comprehensively (Wilkins 1994, figure 2). The overlays had a matt coating and this reduced the contrast of the text beneath (defined as the difference in luminance of background and letters, divided by the background luminance). With directional lighting normal to the surface and 45° oblique viewing, the reduction in contrast was similar for all colours and about 2%. With diffuse illumination

(1) Available as the *Intuitive Overlays®* from IoO Marketing Ltd, 56–62 Newington Causeway, London SE1 6DS.

from overhead fluorescent luminaires the reduction in contrast was generally less than 5%, unless there was clearly evident specular reflection of the light source in which case the reduction in contrast could be as much as 80%. Specular reflection of the light source was avoided.

2.2.2 *Rate of Reading Test.* The Rate of Reading Test[(2)] has been described previously (Wilkins et al 1996). The child is required to read a series of randomly ordered common words arranged as a paragraph of small closely spaced text (Times 9 pt set solid with 4 pt interword spacing). The test consists of ten lines, each with the same fifteen high-frequency words in a different random order.

2.2.3 *Arrows Test.* Items from the Arrows Test are shown in figure 1. The observer's task was to identify the direction in which the arrow was pointing. The arrowhead consisted of seven elements, grouped so that the appearance of an arrow was easy to discern, three elements forming the shaft of the arrow with two for each flèche. The elements were patches of checks consisting of black and white square pixels. The separation of the elements on the flèche was about 30 pixels and on the shaft about 36. The elements were superimposed on a background consisting of randomly disposed black square pixels. The test consisted of twelve plates each with a single arrow pointing up, down, left, or right, superimposed on a background of random texture. The number of the squares in the background texture increased from one test item to the next, increasing the difficulty. Two versions of the test were used. In version 1 the plates measured 148 pixels square (50 mm square in experiment 1 and one condition of experiment 2, and 150 mm square in the other condition of experiment 2). In version 2, used in experiments 3 and 4, the plates were 73 mm square. In version 1, the checks were 6 by 6 pixels and the proportion of black pixels in the background textures increased from 0% in steps of 5% for items 1 – 11 with both items 11 and 12 having 50% density. This version of the test had twelve plates to an A4 page in three columns of four, portrait orientation (although the plates that were 150 mm square were presented one to a page). In version 2 the proportions of black pixels used for the first six items were 5%, 20%, 20%, 30%, 35%, and 40%, respectively, and 50% for the remainder. The checks were 6 by 6 pixels for items 1 – 9 and 5 by 5 pixels (13 white and 12 black) for the last three items. In this version of the test the plates were printed six to a page in two rows of three in landscape orientation. In both versions the plates were printed by means of a 300 dots per inch laser printer in black ink (Michelson contrast about 0.9) on white paper with a CIE 1976 UCS chromaticity of $u' = 0.209$, $v' = 0.475$ relative to a Halon standard.

In the early test items the average density of the arrow was lower than the surround, providing information as to the orientation of the arrow in low-spatial-frequency components of the image. This was not the case for the later items, where there was no relevant information in the low-pass image because the average density of the elements was similar to that of the surround.

2.3 *Procedure*

A viewing distance of about 0.4 m was used. The lighting was a combination of fluorescent and daylight, and the mean luminance of a page was usually greater than 70 cd m^{-2}.

After taking a history, the examiner asked each child to observe a passage of random letters arranged in strings one to seven letters long to resemble text (Overlays Test Material B; IoO Marketing, London). The passage was covered in turn by each overlay in the set of ten overlays, nine coloured and one grey, following the prescribed order of presentation. Each overlay was placed over the page, following the recommended

(2) Available as the *Wilkins Rate of Reading Test*® from IoO Marketing Ltd, 56 – 62 Newington Causeway, London, SE1 6DS.

procedure, and the child invited to say whether the colour made any difference to the clarity of the text. Those colours that improved clarity were then compared side by side, and, by a process of elimination, the optimal colour was selected. The colour was provided by a single overlay, or two overlays, one superimposed on another of similar hue.

The children undertook the Rate of Reading Test; a test of reading speed which required each child to read aloud random words as quickly as possible.

The child's reports, the clinical profile, and the results of the Rate of Reading Test were used to make a decision as to whether or not to provide an overlay. All overlays were provided free of charge.

At the end of the above routine assessment children took part in the Arrows Test of texture segregation.

3 Experiment 1

3.1 *Methods*

3.1.1 *Subjects.* 16 boys and 10 girls aged 6 – 15 years (mean 11 years) took part. They were assessed by the Norfolk Sensory Support Service between 17 and 28 July 1996.

3.1.2 *Procedure.* The Rate of Reading Test and then the Arrows Test version 1 were undertaken with and without various coloured overlays. The overlays included one having the colour previously selected as most effective in improving clarity ('best' overlay) and two identical grey overlays. When superimposed on a white page the grey overlays had a photopic reflectance of about 0.5, similar to that of the coloured overlays, and varying similarly with the angle of view owing to a matt coating. One of the grey overlays bore a label with the word 'Prototype'. The children were told that the 'Prototype' was scientifically designed, that they were one of the first children to use this overlay, and that they were to give it their best effort. Four experimental conditions resulted (best overlay, grey overlay, prototype overlay, and no overlay) and these were given in random order.

3.2 *Results*

The results of the Rate of Reading Test are summarised in table 1 which shows the reading speed in words per minute under each experimental condition. A repeated-measures analysis of variance revealed a significant effect of overlay condition ($F_{3,75} = 6.3$,

Table 1. Means (with standard deviations in parentheses) for reading speed (in words per minute) and texture-segregation test scores (maximum 12) for the best-overlay, grey-overlay, prototype-overlay, and no-overlay conditions of experiment 1; the best-overlay and no-overlay conditions of experiment 2; and the four experimental conditions of experiment 3 (ie with no overlay, with a grey overlay, with an overlay of the colour reported as least beneficial, and with an overlay reported as most beneficial).

Test	Overlay condition				
	none	grey	'prototype'	'worst'	'best'
Experiment 1					
Rate of Reading	67 (26)	71 (27)	70 (29)		76 (29)
Arrows	9.6 (2.2)	9.8 (2.2)	10.1 (1.9)		10.6 (1.9)
Experiment 2					
Rate of Reading	65 (29)				71 (28)
Arrows					
small plate	6.2 (2.9)				6.7 (2.9)
large plate	6.4 (2.4)				7.8 (2.7)
Experiment 3					
Rate of Reading	70 (23)	76 (23)		74 (21)	85 (18)
Arrows	6.4 (2.8)	7.0 (3.0)		7.2 (3.1)	7.9 (2.6)

$p = 0.0007$) which accounted for 21% of the total within-subject sum of squares. [A repeated-measures analysis of variance revealed a significant effect of test order, reading rate improving with practice ($F_{3,75} = 6.78$, $p = 0.0004$). The sample size was insufficient to allow complete balancing for order, but the experimental conditions were presented in a random order and the order did not happen to be preferential to any condition, as revealed by testing for randomisation by using a repeated-measures analysis of variance of the test orders ($F_{3,75} = 0.50$, $p = 0.68$).] A posteriori pairwise comparisons of the four experimental conditions were undertaken by the Peritz procedure (Toothaker 1991) with an experimentwise alpha rate of 0.05. They yielded a significant difference between the performance with the 'best' overlay and each of the remaining conditions, although none of the other pairwise comparisons was significant. Note that the children did not read faster with the 'prototype' grey overlay than with the other grey overlay (the difference did not approach significance, even with a planned paired one-tailed t-test, $t_{25} = 0.30$, $p = 0.38$).

Table 1 shows the number of items correct on the Arrows Test of texture segregation. A repeated-measures analysis of variance of the scores revealed a nonsignificant effect of condition ($F_{3,75} = 2.54$, $p = 0.13$).

The Pearson product-moment correlation between scores on reading speed and texture segregation (without any overlay) was 0.11 (df = 24) and nonsignificant.

The improvement in reading brought about by the use of the optimal overlay (score on optimal overlay divided by score with no overlay) correlated significantly with the improvement in texture segmentation (Pearson $\rho = 0.46$, df = 24, $p = 0.018$, two-tailed).

3.3 *Discussion*

The coloured overlay improved the speed with which the children read aloud randomly ordered common words, although the effect on scores on the text of visual texture segregation did not reach significance. The degree of improvement on the two measures was correlated. In the next experiment the test of texture segregation was revised to see whether it could be improved by increasing the size of the test plates.

4 Experiment 2

4.1 *Methods*

4.1.1 *Subjects.* 15 boys and 7 girls aged 7 – 14 years (mean 11 years) took part. They were assessed by the Norfolk Sensory Support Service between 8 July and 18 November 1996.

4.1.2 *Materials.* Two versions of the Arrows Test were prepared, both based on version 1, one reproduced with panels 50 mm square and the other with panels 150 mm square.

4.1.3 *Procedure.* The Rate of Reading Test was followed by both versions of the Arrows Test in random order. The tests were administered with and without the overlay chosen as giving greatest clarity ('best' overlay) in random order.

4.2 *Results*

The results are summarised in table 1. A two-way analysis of variance was performed with overlay condition (no overlay, 'best' overlay) and test size (large, small) as factors. The effect of overlay was marginally significant ($F_{1,24} = 4.1$, $p = 0.05$), but the main effect of test size was not ($F_{1,24} = 0.5$, $p = 0.50$). The interaction term was significant ($F_{1,24} = 5.1$, $p = 0.03$) suggesting a slightly larger benefit of the overlay for the larger patterns than for the small.

The correlation between scores without an overlay on rate of reading and texture segregation (mean of both test sizes) was significant (Pearson $\rho = 0.48$, df = 20, $p = 0.02$, two-tailed). The correlation between the improvement in reading speed and in texture segregation brought about by the use of the overlay (defined as in experiment 1) was not significant (Pearson $\rho = 0.32$, df = 20, $p = 0.15$, two-tailed).

4.3 *Discussion*
In experiment 3 the Arrows Test was revised in an attempt to increase the number of items on which errors were made.

5 Experiment 3

5.1 *Methods*

5.1.1 *Subjects.* 21 boys and 13 girls aged 8 – 17 years (mean 11.5 years) took part. They were assessed by the Norfolk Sensory Support Service between December 1996 and September 1997.

5.1.2 *Procedure.* Children took part in the Rate of Reading Test before the Arrows Test, version 2. Each test was given in four randomly ordered conditions: (i) with no overlay; (ii) with a grey overlay; (iii) with the overlay reported as having the greatest perceptual benefit, and (iv) with the overlay reported to have the least benefit.

5.2 *Results*
The results are shown in table 1. Repeated-measures analyses revealed a significant main effect of overlay condition for Rate of Reading Test ($F_{3,99} = 14.8$, $p = 0.0000$) and Arrows Test scores ($F_{3,99} = 5.08$, $p = 0.003$). A posteriori pairwise comparisons of the four experimental conditions were undertaken by means of the Peritz procedure with an experimentwise alpha rate of 0.05. The 'best' overlay gave a rate of reading that was significantly greater than that in the three other conditions. The grey overlay was superior to no overlay, but the 'worst' overlay did not differ significantly from the no-overlay or grey-overlay conditions. For the Arrows Test scores there was only one significant comparison, that between the 'best'-overlay and no-overlay conditions.

The Pearson product-moment correlation between the scores with no overlay on the Rate of Reading Test and the Arrows Test was 0.52 (df = 32, $p = 0.0016$, two-tailed), indicating that texture segregation was related to reading speed. The correlation between the degree of improvement in reading speed and in texture segregation brought about by the use of the overlay was also significant (Pearson $\rho = 0.62$, df = 32, $p = 0.0001$, two-tailed).

5.3 *Discussion*
Experiment 3 showed that optimal overlays improve rate of reading and texture segregation more than adverse or grey overlays. Although this result could have reflected an effect of motivation, no such effect was observed in experiment 1 in which motivational instructions were deliberately manipulated. All three experiments are consistent in showing improved reading fluency and two show improved texture segregation with the overlay selected as optimal. The participants in these experiments were children who were referred to the Norfolk Sensory Support Service. The question arises as to whether the beneficial effects of colour are confined to children with reading difficulties, or whether they occur in age-normal readers. In the next experiment, unselected children with normal vision took part.

6 Experiment 4

6.1 *Methods*

6.1.1 *Subjects.* All the 203 children aged 7 – 11 years in a middle school in Norwich took part in a survey of overlay usage.

6.1.2 *Procedure.* The children were examined with overlays at the beginning of the school year (October 1995) and 81 (40%) of the children reported that one or more of the overlays improved the clarity of text. Half of the children who reported benefit from the overlay were given the 'best' overlay immediately to use as and when they wished. The remaining children were given the overlay 3 months later at the beginning of the spring term. During the spring term the children received an optometric examination.

At the end of the school year in July all the children were reexamined. The children took part in the Rate of Reading Test without and with an overlay. Next they took part in the Arrows Test version 2 once with and once without an overlay in random order. The children who did not originally choose an overlay as improving the clarity of text were tested with a randomly chosen overlay.

Last, all the children undertook a test of visual acuity. The children were asked to read a chart with rows of five letters of similar size, the size decreasing from one row to the next (Lighthouse near-acuity LOGMAR chart). The acuity was measured separately for each eye, right eye before left, in one of two conditions presented in random order. One of the conditions involved the use of a coloured overlay placed over the chart, the preferred overlay in the case of children who had chosen an overlay, and a randomly chosen overlay for the remainder. The other condition involved either no overlay or a grey overlay, chosen at random so that half the children viewed the chart without an overlay and half with a grey overlay.

6.2 *Results*

Only the data for the 133 children (57 boys and 76 girls) with normal (6/6) near acuity as assessed during the optometric examination are included in the analyses that follow.

A repeated-measures analysis of variance with overlay condition (with/without) and practice (first/second presentation) as factors revealed a highly significant main effect of overlay condition on rate of reading ($F_{1,132} = 29.1$, $p = 0.0000$) and no significant effect of practice or interaction term.

The mean rate of reading and texture-segregation scores obtained at the end of the school year are shown in table 2 separately for children who (i) were still using their overlay, (ii) had ceased to use the overlay, and (iii) were never given an overlay because they reported no perceptual benefit with any overlay when initially examined. The overlay provided for a 10.7% improvement in rate of reading ($t_{35} = 4.8$, $p = 0.00001$, paired t-test, one-tailed, collapsed over practice) for the thirty-six children who were still using their overlay when examined in the summer term. The children who were no longer using the overlay showed only a marginally significant improvement ($t_{42} = 2.0$, $p = 0.02$, one-tailed), and those who never used an overlay and who were tested with a randomly chosen coloured overlay showed only a 4% improvement ($t_{53} = 2.6$, $p = 0.01$, one-tailed). The improvement in texture-segregation scores on the Arrows Test was also significant for the children who were still using the coloured overlay ($t_{35} = 2.7$, $p = 0.005$,

Table 2. Means (with standard deviations in parentheses) of scores on Rate of Reading Test (in words per minute) and the Arrows Test (maximum score 12) with and without an overlay, shown separately for the children who used the overlay consistently, those who ceased to use it, and those who never received an overlay because they failed to report any perceptual benefit when first examined. The first two groups were tested by using an overlay selected as 'best' for perception, and the last with an overlay selected at random.

Test	Overlay		
	none	best	random
Still using overlay ($n = 36$)			
Rate of Reading	90 (24)	100 (22)	
Arrows	7.8 (2.9)	8.8 (3.0)	
Stopped using overlay ($n = 43$)			
Rate of Reading	106 (21)	108 (23)	
Arrows	8.4 (2.7)	8.7 (2.9)	
Never used overlay ($n = 55$)			
Rate of Reading	92 (28)		96 (27)
Arrows	8.1 (3.1)		8.7 (3.4)

paired t-test, one-tailed), averaging 19.3%. There were no differences in Arrows Test scores for the remaining two groups.

Across all 133 children there was a significant Pearson product-moment correlation between the scores with no overlay on the Rate of Reading Test and the Arrows Test (Pearson $\rho = 0.33$, df $= 131$, $p = 0.001$). The correlation between the percentage improvement in reading speed and in texture segregation brought about by the use of the coloured overlay was $\rho = 0.18$, df $= 131$, $p = 0.03$.

Acuity was scored on the basis of the total number of letters correct. There were no differences for either eye between scores for individuals examined with no overlay or a grey overlay. When acuity scores with a coloured overlay were compared with those with no overlay or with a grey overlay there were no significant effects upon acuity, although acuity was slightly poorer with a coloured overlay than with none (but by less than one letter on average). A difference might have been expected because of the reduction in contrast due to diffusion from the matt coating on the overlay.

6.3 *Discussion*

The children who continued to use the overlay were, in general, those who demonstrated improved reading and texture segregation with the overlay. The children who stopped using the overlay were those who did not benefit from it. They were children who had experienced the overlay and had found it of little help. They differed in this respect from the children who never used their overlay in that the latter may have included some children who, had they been offered an overlay to try out, might have found it useful. The small benefit from overlays in this last group may be interpreted in this light.

7 General discussion

By demonstrating a benefit from coloured overlays in a visual task that does not involve reading, we have provided further evidence that there are children whose reading problems are partly visual and may be treated with colour. This is not to suggest that the Arrows Test is optimal or that other ways of examining texture segregation might not prove preferable.

The instructions concerning the 'prototype' were not associated with a change in reading rate or texture segregation. It is possible, but unlikely, that the instructions had no effect on motivation, but even if this was the case it remains difficult to attribute the beneficial effects of overlays simply to motivation, given the pattern of results. Subjects who were faster readers were also in general those who were good at texture segregation regardless of overlay usage. This correlation between reading rate and texture segregation (significant in three of the four experiments) might be attributed to some general intellectual factor, but such an explanation is insufficient to interpret the fact that the children for whom the overlay was most effective at improving reading speed were also, in general, the children for whom the overlay was most effective at improving texture segregation. (The correlation between improvement on the two tests was significant in three of the four experiments.)

Taken together, the association in the performance on reading and texture segregation, and the improvement with overlays on both tasks combine to suggest that (i) visual-perceptual difficulties may affect the reading abilities of schoolchildren; (ii) such difficulties may be quite common, given the high prevalence of overlay usage in these and other studies (eg Tyrrell et al 1995; Jeanes et al 1997), and (iii) coloured overlays may reduce the visual-perceptual difficulties.

The beneficial effects of coloured overlays and lenses have been attributed (Solman et al 1992; Williams et al 1992) to an effect of colour on the deficit in magnocellular function seen in some poor readers (Lovegrove et al 1986). However, there is nothing in this idea that explains the individual differences in colour efficacy, and the benefits occur in good readers as well as poor. A theory of visual stress has been proposed (Wilkins 1995). According to the theory (i) certain visual stimuli result in a strong physiological input. (ii) These 'strong' stimuli can provoke seizures in patients with photosensitive epilepsy and arguably also (iii) discomfort in patients with migraine by virtue of a minimal diffuse failure of cortical inhibition in these patients. (iv) The same strong stimuli result in perceptual distortion in other individuals owing to (v) a spread of excitation causing visual neurons to fire inappropriately. (vi) Individuals with migraine are particularly susceptible to the distortions and show a consistency not shown by controls with respect to the colours chosen as aversive for reading. (vii) Children who benefit from colour usually have migraine in the family. (viii) Coloured filters give rise to a change in the distribution of excitation within the cortex owing to (ix) the very different spectral sensitivities of cortical neurons. (x) Text approximates a grating and can have parameters within the epileptogenic range. (xi) Colours that are selected as 'comfortable' reduce excitation in hyperexcitable regions. We have shown that gratings mask optically superimposed low-contrast targets (Chronicle and Wilkins 1996). The extent of masking is critically dependent on spatial parameters of the gratings and gratings with 'stressful' parameters are particularly effective at masking. The 'noise' background used in the Arrows Test is less extreme than epileptogenic gratings, but its effectiveness as a 'mask' may be sufficient to reveal the individual differences in susceptibility referred to above.

Printed text forms a visual texture, particularly for those observers who are not yet familiar with its meaning. The texture-segregation task used here is similar to reading in so far as it requires integration of information from successive fixations across a highly contrasting texture, with a large consequential change in the contrast of the retinal image from one fixation to the next. Breitmeyer (1980) has argued that the perception of text during reading requires the repeated inhibition of images obtained on successive fixations. Such 'transient-on-sustained' inhibition may be necessary in texture segregation as well.

When the density of the background resembles that of the seven elements that form the arrow, the individual elements cannot all be seen on the same fixation. Observers are usually quite unaware of this, as indeed people generally are of the variations in spatial resolution across the visual field. The arrow, once perceived, is seen as a whole and retained as a transsaccadic 'memory', and it is the formation of this memory that may be disrupted by the change in contrast from one fixation to the next.

Colour contrast is already known to play an effective role in segregating visual texture. Indeed it is the advantage conferred in this way that may have led to the development of trichromacy (Mollon 1989). Conversely, camouflage is effective because the contrast between colour boundaries interferes with the perception of other more salient contours. We have dealt here not with colour contrast but with the average chromaticity of the entire texture. We have presented evidence for a completely new role of colour in the segregation of visual texture. We have shown that for some observers the overall colour of a texture can influence the perception of targets defined only in terms of the difference between their texture and that of the surround.

There are several clinical tests that take advantage of the ability to discriminate visual texture in order to measure some other aspect of visual function, such as colour vision in the case of the Ishihara test (Kanahara Shuppan Co Ltd, Tokyo, Japan), and stereopsis in the case of the Randot stereograms (Stereo Optical Co Inc, Chicago, IL, USA). The present findings suggest that there may exist individual differences between observers in the ability to discriminate texture. When extreme, these individual differences may have consequences for the interpretation of the above clinical tests.

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