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# A comparison of colour and visual texture as codes for use as area symbols on thematic maps

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Three experiments compared colour and texture as methods of coding area symbols for thematic maps. Most previous research has been limited to displays with, at most, eight codes. This study employed displays containing 16 types of symbol coded either by colour, texture, or a non-redundant combination of the two. Symbols coded by colour, or a combination of colour and texture were much easier to find than symbols coded by texture alone. Point symbols were easier to locate against a coloured background than a textured background. Texture codes may be slightly easier to remember than colour codes but the difference, if any, is small.

## 1. Introduction

The information shown on maps can be conveniently divided into three kinds: *point*, *line* and *area*. Oil wells, churches and triangulation points are examples of point information, while railways, pipelines and rivers are examples of line information. This paper, however, is concerned with the third category: area information. On topographic maps, this often includes woodland, built-up areas and administrative regions. But area symbols play a much more important role on thematic maps such as those showing the soil type, geology, vegetation or land use.

Most typically, colour codes are used to differentiate these classes of information on thematic maps. For example, on a vegetation map a particular shade of green may show that the principal vegetation is coniferous forest. This allows the map reader both to identify the vegetation at a particular location, and to see its extent. Less commonly, areas are coded by visual textures such as dots, stripes and cross-hatching printed in a single colour. Sometimes, colour codes and texture codes are used in combination as, for example, on the United Kingdom 1 : 25 000 Land Use maps.

This study compared people's performance in using codes based on either colour, texture, or a combination of the two. The investigation was limited to qualitative rather than quantitative applications: the ordered layer tints often used to portray relief in atlases present their own special problems and so are not discussed here (see Phillips *et al.* 1975).

Search tasks seem especially appropriate for map reading research because most map reading tasks have a large search component (Hitt 1961). Many experiments have demonstrated that search is faster for targets coded by colour than those coded by shape (e.g., Christner and Ray 1961, Hitt 1961, Smith and Thomas 1964, Williams 1967, Luria and Strauss 1975, Poulton and Edwards 1977). All of these tested displays with no more than eight colour codes, but thematic maps nearly always require more than eight area symbols. Sometimes thematic maps require as many as 30 or 40 symbols and then colour coding alone is inadequate because of the confusions which result. Map designers usually solve this problem by placing alphanumeric codes within each

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coloured area both on the map and in the legend. This type of partially redundant colour coding has been investigated by Shontz *et al.* (1971) where targets on aeronautical charts were coded with spots in either seven, 14 or 28 colours. The number of coded objects was held constant and the colour code was partially redundant because subjects were given a sketch showing the geographical context of their target. Although search times decreased as the numbers of colours increased, the difference was not statistically significant.

The present study employed displays with 16 codes which is a small enough number not to need the addition of redundant alphanumeric codes, but is still large enough to be representative of map design. When displays have 16 texture patterns printed in a single colour the literature would predict relatively slow search times. With 16 colours search should be fast but there may be a danger of confusions, even though the colours have been carefully chosen for discriminability (see, for example, Halsey and Chapanis 1951). Therefore, the best design solution may be a combination of colour and texture.

The probability of confusing colours is likely to depend on the length of time for which it is necessary to remember a colour. Therefore Experiment 1 used two types of task: *search* and *memorize and search*. In the *search* task the target appeared on the same page as the display, but in the *memorize and search* task the target was on the previous page. Although this puts only a very modest demand on memory, it is typical of the short delay which occurs when reading a larger sheet map between reading a symbol in one corner of the map and matching it to the legend in the opposite corner.

As well as comparing colour and texture, the first experiment also investigated the effect of printing black holding lines between areas of colour. These black lines are often printed to disguise poor colour registration although Robinson and Sale (1969) claim they may reduce induced colour effects. The addition of black lines between colours tends to make the colours appear brighter and more saturated, but it is unclear how this would affect their use as codes. Experiment 1 compared displays where holding lines were present or absent.

## 2. Experiment 1

### 2.1. *Displays*

Test material was specially printed by offset lithography. There were six types of display: one colour, two colour, four colour, eight colour, 16 colour and 16 colour with lines. The one colour display is illustrated in figure 1. Each display was an A4 page (296 × 210 mm) printed with an eight by eight grid of 20 mm squares. Each square was coded by its colour, its texture or a combination of the two. Each display had 16 different codes each of which occurred in four squares randomly distributed across the display, although the same code never occurred in adjacent squares.

In the one colour display, there were 16 texture codes printed in one colour. In the two colour display, eight textures were printed in combination with two colours, making 16 codes in all. In the four colour display, four colours were combined with four textures. In the eight-colour display, eight colours were combined with two textures. In the 16 colour display, 16 colours were printed solid, that is without a texture pattern. The 16 colour with lines display was identical to the 16 colour display except that a grid of black lines about 0·2 mm wide was printed around and between the coloured squares. No other displays had black lines.

Details of the colours and textures are given in table 1. They were carefully chosen for discriminability by three judges, one of whom was a graphic designer, working

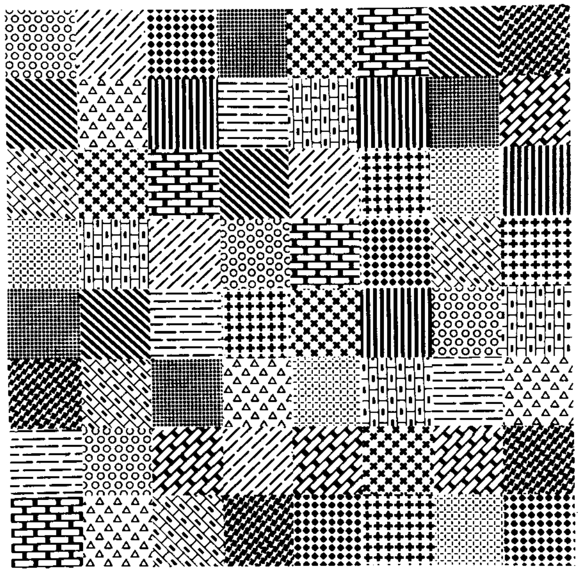

Figure 1. The one-colour display illustrated here is a random arrangement of 16 texture patterns each appearing in four squares. The original was printed in blue. (For reference, the patterns are numbered according to their first position in a normal reading sequence, so, for example, texture pattern 10 is triangles and 11 is vertical stripes.)

under the lighting conditions used in Experiments 1 and 3. The choice was made from alternatives normally available to the map designer. Colours were chosen from those which could be printed with three process colours and a limited number of printing screens. The textures were from the Letratone range. The displays were printed on 85 gsm white cartridge paper.

### 2.2. *Subjects and design*

Subjects were randomly assigned to one type of display which they used throughout the experiment. Approximately equal numbers of subjects where tested on the six conditions. They were 44 men and 57 women aged between 17 and 40 years (median 18 years) and all were university students with normal colour vision as defined by the Ishihara tests. They were paid volunteers and were tested in two groups. A number of other unrelated experiments were conducted in the same session.

### 2.3. *Test booklets*

Test booklets were constructed by stapling together the display pages. Each page was always the opposite way up from the page that preceded it and the page that followed it to make it difficult for subjects to learn the displays. The booklets had title pages printed with the instruction: 'Important. Do not open this booklet until you are told'.

Each subject had four booklets. Booklets 1 and 3 were used for the *search* condition and both consisted of eight display pages. At the top of each page was fixed a target square cut from a display of the same type. All the codes were used equally often as targets and were selected at random, although the same target never occurred in any two consecutive pages. In Booklets 2 and 4, which were used for the *memorize and search* conditions, there were also eight display pages, but here the targets were fixed on blank pages which preceded each display.

Table 1. Details of the colour and texture codes tested in Experiment 1. Colours are described by their approximate Munsell notation and the specification used for printing them. Three printing inks, yellow (Y), red (R), and blue (B) were combined with printing screens of 10%, 20%, 50% or 100% (solid printing). Texture patterns are numbered by the first position they occur in figure 1.

| Approximate Munsell notation | Printing specification |
|---|---|
| Sixteen-colour display | |
| Sixteen colours printed solid (no texture pattern). | |
| 2·5YR 5/14 | 100Y, 50R |
| 7·5Y 9/10 | 100Y |
| 10GY 6/10 | 100Y, 50B |
| 2·5PB 6/10 | 10R, 50B |
| 10YR 9/1 | 20Y, 10R, 10B |
| 7·5RP 6/10 | 50R |
| 2·5B 7/6 | 20Y, 50B |
| 2·5P 9/4 | 10R, 10B |
| 5Y 9/10 | 100Y, 10R |
| 7·5Y 9·5/2 | 20Y |
| 10Y 9/12 | 100Y, 10B |
| 7·5GY 9·5/2 | 20Y, 10B |
| 10B 9/2 | 10B |
| 2·5P 4/10 | 50R, 50B |
| 2·5Y 3/4 | 100Y, 50R, 50B |
| 5RP 9/4 | 10R |
| Eight-colour display | |
| The first eight colours shown above printed in texture patterns 3 and 11. | |
| Four-colour display | |
| The first four colours shown above printed in texture patterns 3, 11, 16 and 22. | |
| Two-colour display | |
| Two colours both printed in texture patterns 1, 3, 11, 12, 13, 16, 22 and 23. | |
| 10B 6/16 | 100B |
| 7·5RP 6/16 | 100R |
| One-colour display | |
| One colour printed with 16 texture patterns, as illustrated in figure 1. | |
| 10B 6/16 | 100B |

### 2.4. *Procedure*

Subjects were asked to look at an example of the display they would be using which appeared at the beginning of Booklet 1. They were told that they would have to search for examples of the codes used in the display, and were warned that codes were often similar; for example, there might be two shades of the same colour, or the same texture pattern in different orientations. With Booklets 1 and 3, they were asked to cross out the four squares in the display which matched the target at the top of the page. With Booklets 2 and 4, they were asked to look at the target and then cross out any two examples of it in the display on the following page. As this was the memory condition they were not allowed to turn back. They were told to work through each booklet as quickly as possible, and to stop and close the booklet as soon as they heard a buzzer. The time limit was half a minute for each booklet. They tackled the booklets in the numbered order with a short break between each one. The experiment was conducted in a lecture theatre with good quality fluorescent lighting (Thorn tubes type 3500 White).

## 2.5. *Results*

A few subjects crossed out the wrong number of squares on each page and their data on these booklets were rejected: there were three rejections on Booklet 1, two on Booklet 2, six on Booklet 3 and 10 on Booklet 4.

Figure 2 shows the mean number of correct responses and errors for the four booklets under the six conditions. The maximum possible score for Booklets 1 and 3 was 32 and for Booklets 2 and 4 it was 16. A separate analysis of variance was carried out on the number of correct responses for each booklet and all showed statistically significant differences between the six conditions (Booklet 1, $F(5,92)=9{\cdot}6$, $p<0{\cdot}001$; Booklet 2, $F(5,93)=7{\cdot}6$, $p<0{\cdot}001$; Booklet 3, $F(5,89)=11{\cdot}7$, $p<0{\cdot}001$; Booklet 4, $F(5,85)=11{\cdot}4$, $p<0{\cdot}001$). These were one way analyses of variance for independent groups and fixed effects, with no covariates. The results of four Duncan's multiple range tests are shown in figure 2. Duncan's is a weaker test of the possible hypotheses than the extraction of linear and quadratic components, but it was chosen as most suitable for the practical application of the results. In every case, the one colour condition was significantly worse than any of the others. On Booklet 1, the two- and four-colour conditions differ significantly from both of the 16 colour conditions.

As figure 2 shows, error rates were low and there were no significant differences even when data were pooled across booklets.

All four booklets show a similar pattern. There is a rise in scores as more colours are introduced into the code, except for a small drop in performance on the four-colour displays. There is an especially large increase in score going from one-colour to two-colour displays and no difference is apparent between the 16-colour displays with lines and without lines.

Although error rates were low, there was some consistency in the types of error which occurred. On the eight- and 16-colour displays most errors were confusions between colours which were close together in the colour space.

With the four-colour displays, 28 out of the 34 errors were confusions between a single pair of codes: diamond shapes (pattern 3) and crosses (pattern 22) both printed in yellow (Munsell 2·5Y 9/10). It was clear that the contrast between this yellow and the white of the paper was insufficient to see the texture patterns easily and this may be the

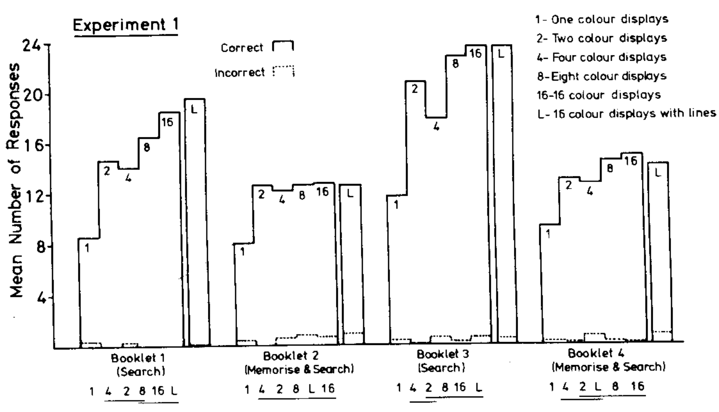


Figure 2. The mean number of correct and incorrect responses in Experiment 1. The results of a Duncan's multiple range test adopting the $p<0{\cdot}05$ level on the means for correct responses is shown for each booklet. Conditions underlined by the same line do not differ significantly from each other.

cause of the relatively poor performance on four-colour displays evident in figure 2. We doubt whether a different yellow ink would have been better: one map designer has advised us (too late!) that texture patterns printed in yellow are always difficult to discriminate.

There were very few errors on the two-colour display. On the one-colour display, 17 out of 24 errors were confusions between one code and another which was the same pattern rotated through 45°—the worst case was 10 confusions between crosses (pattern 22) and *X*s (pattern 5).

### 2.6. *Discussion*

On the *search* tasks the number of targets found increased with the number of colours in the display. The biggest jump occurred between one colour and two colours. The slight drop with four colours was probably due to the poor discriminability of texture patterns printed in yellow. The results for the *memorize and search* task were similar but there was less evidence of an increase between two colours and 16 colours, particularly on Booklet 2.

Neither task supported the prediction that the 16-colour display would be worse than the eight-colour display because of discriminability problems, although the flatter histograms with the *memorize and search* task might indicate that remembering colours was causing difficulty.

There was no difference in performance between the 16-colour display and the 16-colour-with-lines display. Although black holding lines alter the appearance of colours, they do not seem to affect performance.

## 3. Experiment 2

Williams (1967) has recorded the eye movements of subjects searching displays containing symbols of different shapes, sizes and colours, similar to point symbols used on maps. Subjects made a series of rapid eye fixations, nearly all of which fell on or near one of the shapes. When they knew the colour of their target, over half of their eye fixations fell on stimuli of the correct colour. When they knew the size of the target, there was a weaker tendency to fixate stimuli of the correct size. But when they knew the shape of the target, the frequency of fixating stimuli of the correct shape was only a little above the level expected by chance. Peripheral vision must play an important part in the search process. While a person is fixating on one stimulus he must decide where to place his eyes next, on the basis of information available in peripheral vision. Williams's results suggest that colour codes are easy to distinguish in peripheral vision, size codes are more difficult, and shape codes more difficult still.

Williams was testing point symbols. If similar processes also affect area symbols, this would help to explain the results obtained in Experiment 1. In Experiment 2, eye movement records were recorded from four subjects while they searched for colour and texture codes.

### 3.1. *Eye movement apparatus*

A Polymetric V-1164-3 Eye Movement Recorder linked to a PDP-12 computer was used to record subjects' eye fixations. The apparatus is similar to that described by Mackworth and Mackworth (1958) and uses a corneal reflection monitored by a television camera. The television picture is divided into a grid of 15 by 15 cells, and the computer samples the position of the corneal reflection in this grid every 20 ms.

### 3.2. *Displays*

Colour slides were prepared from the one-colour, two-colour, eight-colour and 16-colour displays. The four-colour display and 16 colour-with-lines display were not used. When back projected, these slides gave a good reproduction of the material used in Experiment 1 with colours which came close to those in the original. Each display subtended a visual angle of about 12° and was viewed at a distance of 450 mm. Four codes from the top row of each display were chosen as representative targets.

### 3.3. *Subjects and procedure*

Two men and two women, who were undergraduates with normal colour vision, took part in Experiment 2. One man and one woman made four searches on the 16-colour display, followed by four on the eight-colour display, four on the two-colour display and four on the one-colour display. The other two subjects had the same conditions except that the four displays were presented in the reverse order.

Before each search the experimenter told the subject the position on the top row of the display which indicated the target; for example, 'second from the left'. After the subject had looked at this, he searched for the other three examples of this code and pressed a button when all were found. Subjects were allowed to spend an unlimited time encoding the target in the top row of the display, but they were instructed to search as quickly as possible.

### 3.4. *Results*

On a number of searches subjects made head movements which caused their corneal reflection to move outside the field being recorded. In this way, 19% of eye movement records were lost. On the remaining records the analysis was limited to counting the number of fixations made while searching and calculating the mean duration of these fixations. Fixations were counted from when the eyes left the top row of the display to when the button was pressed. Mean fixation times include the time taken to make the following saccade and so are overestimated slightly. Because of limitations of the apparatus, two fixations which were less than approximately 1° of visual angle apart and which were both of short duration were treated by the computer program as a single fixation.

Means are shown in table 2. An analysis of variance on mean fixation times showed no significant differences ($F(3,9)=1{\cdot}31$, $p>0{\cdot}25$) but there was a clear difference between the number of fixations made on the four types of display ($F(3,9)=11{\cdot}2$, $p<0{\cdot}01$).

### 3.5. *Discussion*

Experiment 2 used only four subjects and tested only four representative targets on each display. Nevertheless, the results give some indication of the processes operating in Experiment 1. There were large differences in the mean number of fixations needed to find the targets. The pattern is similar to Experiment 1: there is a large drop between the one-colour and two-colour displays and smaller differences as more colours are added to the display. Fixation times remain relatively constant and although table 2 suggests a trend for longer times as the number of fixations decreases, this is non-significant. The results agree well with Williams's (1967) data on point symbols and suggest that colour codes are easy to distinguish in peripheral vision but texture codes are more difficult. Although we have no colour vision in the extreme periphery of vision, it is well established that we have some colour discrimination as far out as 20° or 30° from the fovea.

Table 2. The results of Experiment 2. Eye movement records from four subjects.

| Display type | Mean number of fixations | Mean fixation time (ms) |
|---|---|---|
| One colour | 29·4 | 306 |
| Two colour | 16·8 | 325 |
| Eight colour | 11·6 | 337 |
| 16 colour | 8·4 | 346 |

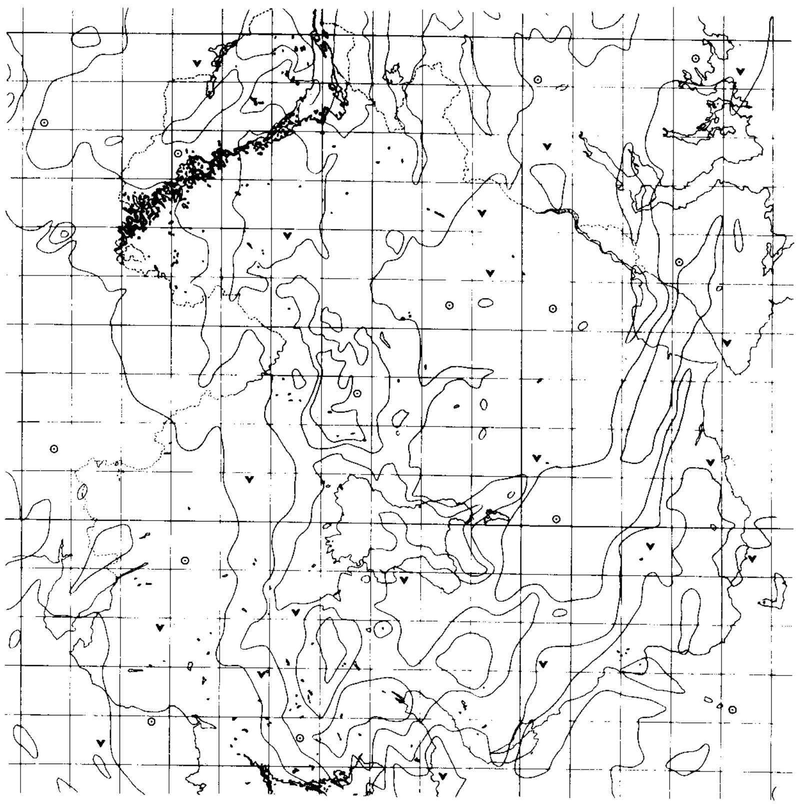

Figure 3. In Experiment 3 the displays were overprinted in black with these map symbols.

## 4. Experiment 3

Experiment 3 was conducted to test the generality of the results from Experiment 1 and to obtain data from some further tasks.

The square grids tested in Experiment 1 clearly differ in several respects from area symbols on maps. An important difference is that they are uncluttered by all the additional information usually printed on a map. In order to add some visual clutter the displays were overprinted with the map symbols shown in figure 3. It is important to know whether this overprinting alters the results found in Experiment 1.

Although Experiment 1 suggested that the 16 colour display is the best of the designs, would a task putting a greater demand on memory qualify this result? One question in Experiment 3 required subjects to remember a code and then find an example of it after doing some simple arithmetic.

When used in the context of a map, would the different types of code affect the legibility of other information equally? Figure 3 includes a number of small point symbols (*V*-shapes and *O*-shapes) which subjects searched for, in order to compare the interfering effect of the colour and texture codes.

4.1. *Material*

The printed sheets for the one-colour, two-colour, eight-colour and 16-colour displays were overprinted in black with the map symbols in figure 3 and were assembled into booklets. Booklet 1 was the same as that used in Experiment 1 except for the overprinting. Booklet 2 contained a three page sequence repeated nine times. This sequence was as follows: a single target square fixed to a blank page, a page with 12 simple subtraction sums (e.g. 76–7 =  ) and an overprinted display page. Each display page was always the opposite way up from the one which preceded it and followed it. In both booklets the single target squares were not overprinted; they were analagous to the map legend which is usually free from visual clutter.

4.2. *Subjects and design*

Fifty-three male and 28 female university students aged between 18 and 46 years (median 20 years) with normal colour vision were tested in five groups, following a similar procedure to Experiment 1. Roughly equal numbers of subjects were randomly assigned to the four types of display.

4.3. *Procedure*

The *search* task on Booklet 1 was identical to that used in Experiment 1: subjects crossed through four targets on each page completing as much as possible in half a minute. They were then shown an enlargement of the *V*-shaped symbol in figure 3 and were asked to circle as many of these on the display as they could in 20 s. The task was repeated with the *O*-shaped symbol. The first two display pages in Booklet 1 were used for this purpose. Because of the short time limit, subjects were instructed to locate the correct page with their thumb before the instruction to turn and start was given. For these searches both pages were positioned in the booklet so that the *V*-shapes were upright.

Booklet 2 was used for the *memory* task which measured the retention of a code after completing some simple arithmetic. The arithmetic interference task was intended to simulate the situation where someone looks at a symbol on a map, turns away for a few moments to make some notes or calculations and then returns to the map and looks for another instance of the same symbol. On each trial subjects had 10 s to learn a code presented as an isolated square, 10 s to complete as many subtraction sums as possible, and a further 10 s to cross through one instance of the code on the display. After a practice trial, subjects worked straight through eight trials, with the experimenter instructing them to turn the page every 10 s.

4.4. *Results*

For the *search* task the mean number of correct targets found (with errors in parenthesis) was 8·9(0·1), 11·8(0·0), 13·8(0·3) and 14·6(0·5) for the one-, two-, eight-, and 16-colour displays respectively. The difference between means was significant ($F(3, 77) = 7{\cdot}93$, $p < 0{\cdot}001$) and a Duncan's multiple range test ($p < 0{\cdot}05$) showed that the one-colour condition differed significantly from all the others, and that the two-colour condition differed significantly from the 16-colour condition. The pattern of results was the same as for Experiment 1, but the differences were smaller.

The means for the number of *V*-symbols found were 12·9, 12·6, 14·7 and 15·8, and for the *O*-symbols, 7·9, 8·1, 11·6 and 12·6, for the one-, two-, eight- and 16-colour conditions respectively. Both were statistically significant ($F(3, 75) = 5·8$, $p < 0·01$, for the *V*-shape, $F(3, 76) = 29·0$, $p < 0·001$, for the *O*-shape). A Duncan's multiple range test ($p < 0·05$) gave the same result for both tasks: there was no significant difference between the one- and two-colour displays, nor between the eight- and 16-colour displays, but all other differences were significant.

On the *memory* task the mean number of errors out of a maximum of eight was 0·41, 0·47, 1·00 and 0·79 for the one-, two-, eight- and 16-colour displays respectively. An analysis of variance was not significant, but a comparison of the combined scores for the one- and two-colour displays with the combined scores for the eight- and 16-colour displays was significant ($F(1, 77) = 5·3$, $p < 0·05$). With the interpolated subtraction task the mean numbers correct (with mean errors in parenthesis) were 40·6(1·8), 37·6(1·4), 38·3(1·4) and 35·5(1·9) for the one-, two-, eight- and 16-colour displays respectively. Analyses of variance were not significant ($p > 0·5$ for correct, $p > 0·25$ for errors) and there is no evidence for a trade-off between memory and arithmetic performance.

### 4.5. *Discussion*

If the means for the *search* task are compared with those from the first booklet in Experiment 1 the pattern is similar but the range is greater in Experiment 1. The procedure was identical except that the pages in Experiment 3 were overprinted. It is possible that overprinting has the effect of reducing differences between the types of coding. However, the basic result is unchanged: the greater the use of colour coding, the faster the search, with the biggest difference occurring between one- and two-colour displays.

Subjects were asked to search for the *V* and *O* symbols to discover how different types of area symbol might affect the legibility of other information on the map. The results suggest that coding based largely or wholly on colour is less interfering than coding based largely or wholly on texture. But it could be argued that the difference arose because of the brightness contrast between the symbols and their background. This is unlikely because, as is clear from table 1, the darkest backgrounds occur in the 16-colour display which produced the best performance.

All the data discussed so far demonstrate the superiority of colour coding over texture coding, but the memory task in Experiment 3 shows a weak effect in the opposite direction. People made very few errors in memorizing the codes, but there were slightly more errors with colours than with textures.

## 5. General discussion

Many experiments have demonstrated that colour codes are quicker to find than other forms of coding. But it was predicted that with as many as 16 colour codes, confusions are likely and the optimum may be a combination of colour and texture coding. This has proved to be wrong and even when heavy demands are put on memory, confusions between colour codes appear to be only slightly more frequent than confusions between texture codes. The 16 colours used in this experiment were chosen carefully and it is likely that a less discriminable set of 16 colours, or a set larger than 16, would show more confusions. However, sets larger than 16 may be advantageous when the colour coding is partially or wholly redundant (Shontz *et al.* 1971), for example, when alphanumeric codes are added to the areas of colour.

The purpose of these experiments was to make recommendations on area symbols for maps. It is important to consider how much the material and tasks employed here can provide results which generalize to map reading. The displays were grids of squares and the map designer may object that areas on real maps come in irregular shapes and sizes. The question of shape and size should perhaps be dealt with separately.

Would irregularly shaped areas give different results from squares? Experiment 2 has shown that colours are faster to search for because we need to make fewer eye fixations. The number of eye fixations almost certainly depends on the information available in peripheral vision and it would seem that colour is easier to discriminate in peripheral vision than texture. It is hard to see how this could be affected by the shape of an area, and with peripheral vision several degrees away from the fovea it is unlikely that people could even tell whether an area is regular or irregular.

The size of the area is a different matter because the smaller an area, the less efficient peripheral vision will be. Small area symbols pose special problems for the map designer. With texture coding the area may be so small that it does not enclose a single repeat of the pattern. On the other hand, small areas of colour are difficult to match to the legend. This is partly because small areas are especially prone to induced colour effects (Kinney 1962) and induced tritanopia may also be a problem (Kaiser 1968). Clearly, the experiments reported here have not tackled this question, but, in the absence of other experimental evidence, intuition suggests that a small area of colour presents fewer problems than a small area of texture where it may simply be impossible to show the texture in the space available.

Are the tasks used here representative of map reading? In a factor analytic study Hitt (1961) showed that a number of different map reading tasks were combinations of two independent factors which he called *search* and *recognition*. It is likely that the search and memory tasks used in the present experiments load heavily on these two factors, and so should be representative of quite a number of map reading operations. However, some types of map will put special demands on the map reader which are beyond the scope of this study. For example, it is sometimes important to see the precise shape of an area, such as the shape of woodland for air navigation (Taylor 1975).

## 6. Conclusions

(1) Cartographic area symbols coded by texture can be printed cheaply in a single colour. But they are relatively difficult to find and superimposed point symbols are also difficult to locate.

(2) Area symbols printed in two colours in combination with a number of textures are much easier to find than symbols coded by texture alone. However, superimposed point symbols will still be difficult to locate.

(3) Area symbols coded largely or wholly by colour are relatively expensive to print but they are easy to find and point symbols which are superimposed are also easy to locate.

(4) Combinations of colour and texture should be chosen carefully. If the contrast between a colour and its background is too small the texture pattern may be difficult to see, for example, yellow on white.

(5) The colour codes and texture codes used in these experiments seem to be of roughly equal difficulty to memorize. Under some conditions textures appear to be slightly easier to remember than colours.

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Dans trois expériences on a comparé des procédés d'utilisation de la couleur ou de la texture pour coder les symboles de surface sur les cartes thématiques. La plupart des recherches antérieures s'étaient limitées à des représentations utilisant, au plus, huit codes. Dans cette recherche, on a utilisé des représentations contenant 16 types de symboles codés, soit selon la couleur, soit selon la texture, ou encore selon une combinaison non redondante des deux. Les symboles codés selon la couleur ou selon une combinaison de la couleur et de la texture étaient plus faciles à repérer que les symboles codés selon la texture seule. Les symboles pointillés étaient plus faciles à localiser sur un fond coloré que sur un fond texturé. Les codes texturés sont sans doute plus faciles à mémoriser que les codes colorés, mais la différence, s'il y en a une, ne peut être que minime.

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