Characterising the emotional response to colour in simple designs

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ABSTRACT

The research concerns the development of relationships between scales of emotional response and instrumental measures of colour. The results of studies of the "exciting-calming" emotional response from 50 observers to 42 simple, two-colour designs are reported. Studies of the response to designs with a central coloured shape on a coloured background showed that the shape of the central colour area (circle, triangle and square) had only a slight influence on the number of "exciting" decisions. The colour of background had a strong influence on the number of "exciting" decisions. The relative area of the central shape to the background shape was found to have a modest influence on the observer responses. It is suggested that the visual contrast between the colour of the central shape and the colour of the background has a strong influence on the response of the observers.

1. INTRODUCTION

It has long been recognised that the colour appearance of objects and of the visual environment affects the mood, sentiment and feeling of wellbeing of an observer. It follows that, through appropriate colour selection, a designer can enhance the aesthetic appeal and reinforce the emotional response to manufactured products and to the built environment. Human emotions induced by colours are commonly expressed through words such as warm and exciting.

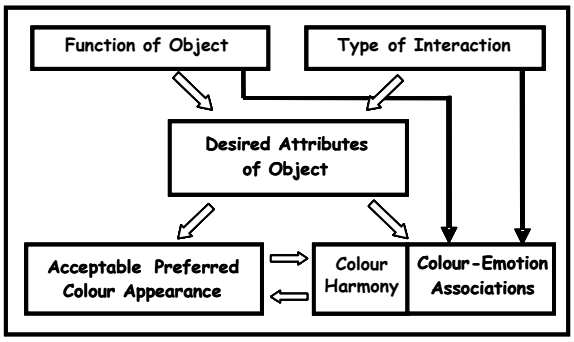

Figure 1: Role of colour-emotion associations in the preferred colour appearance of objects

An objective of the research is the determination of relationships between emotional associations and instrumental measures of colour. Relationships of this type can be developed by the application of logistic analysis and maximum likelihood methods to observer response data[1].

The possible influences of culture on emotion scales of this type have been, and are being investigated, notably by an association of research groups[2] committed to the free exchange of colour-emotion data sets and the development of rigorous methods of analysis. For example visual assessment tests of colour emotion, as expressed by twelve kinds of word pairs, were carried out in the UK, Japan, Thailand and Hong Kong.

Earlier studies[1, 2] were concerned with the study of the response to small, square shaped areas of colour presented against a mid-grey background. This method is used to reduce the influences of function, type of interaction and preference that intrude on the emotional response when recognisable everyday objects are being judged, Figure 1.

Figure 2: Design by Duncan on the ceiling of a hydrotherapy room at the Chelsea and Westminster Hospital, London.

The aim of this research is to be able to suggest the likely "emotional" impact of coloured environments that have been created, or are being

proposed, by architects or interior designers. The notion that the visual environment can enhance health and healing has inspired many research programmes. Several studies have shown that the visual environment has a substantial affect on the anxiety of patients and on the therapeutic benefit of treatments. An example is shown in Figure 2, which shows a geometric design by one of the authors (Duncan). The design, in red, orange, yellow and blue on a white background, decorates the ceiling above the water pool in a hospital hydrotherapy treatment room and is intended to promote feelings of activity, warmth and excitement within the patients[3].

Associated with these studies was the use of the Leeds method[1] of relating the colorimetric description of the colours in the art-works to emotional scales[4, 5]. By these means the Staricoff and Duncan study has produced quantitative evidence of benefit in an area of research that is traditionally described only in qualitative terms.

The Leeds method is based on emotional scales obtained from analysis of the response of observers to single colours presented on a neutral grey background. These types of scale may not be correct for predicting the likely observer response to complex designs such as Figure 2. This paper reports on the development of techniques for studying the response to colours presented in simple designs, where the shape and relative areas within the design could influence the response to the colours used.

2. METHOD

The ceiling design shown in Figure 2 contains square, triangle and circular shaped areas in red, orange, yellow and blue shades and these formed the major part of the shapes and colours studied. The semantic difference method of self-reporting has been used to obtain sensory data describing the ***exciting-calming*** emotional response of observers to the coloured surfaces and designs.

Table 1: Parameters of the colours used in the two-shape designs (D65, 10°)

Colour	L*	a*	b*	% P(Exc)
Red	50.96	48.84	30.15	79
Yellow	87.50	-9.83	78.21	93
Green	35.80	-17.45	2.63	32
Blue	36.13	7.44	-30.47	40
White	92.67	1.53	-5.59	29
Grey	51.25	1.35	-1.03	11

During an experiment, an observer looked at the test panel under controlled conditions and selected the word, exciting or calming, that best described their impressions of the appearance of the panel. Forcing the observer to select one term from a pair allowed the data to be analysed by means of binomial statistics and the logistic function.

Previous studies[1, 2] have made use of a square shaped colour patch presented against a grey background (L* = 50). Equations 1 and 2 are taken from the results of this analysis and are predictive equations for the probability P(Exc) of a single colour being described as ***Exciting***.

$$P(Exc) = 100/[1 + exp(-S)], \text{ where} \tag{1}$$

$$S = \alpha + \beta_1 L^* + \beta_2 C^* + \beta_3 a^* + \beta_4 b^* + \beta_5 C^* \sin(2h + \gamma) + \beta_6 \sqrt{L^{*2} + a^{*2}} + \beta_7 \sqrt{L^{*2} + b^{*2}} + \beta_8 (L^{*2}/100) \tag{2}$$

and α= -0.3520, β_1= -0.0369, β_2= 0.0671, β_3= 0.0098, β_4=0, β_5= -0.0153, β_6= -0.0350, β_7=0, β_8= 0.0579 and γ = -93

In the two-shape design study a coloured patch in the form of a circle, a triangle or a square was presented in the centre of a second coloured area in the form of a circle or a square. Examples of the designs are shown in Figure 3. The panels were presented to the observer under simulated daylight (D65) conditions in a lighting cabinet. The CIEL*a*b* coordinates of the red, yellow, green and blue colours used in the designs are given in Table 1, together with values of P(Exc) determined from equations 1 and 2.

The responses from fifty observers of Asian and European cultural background were recorded for a series of 42 designs in which the influences of colour, shape and relative area were examined. Each observer carried out the experiment twice, each time on separate day, to provide 100 judgements on each of the 42 designs.

3. RESULTS

The results for the coloured shapes on a square shaped white background, similar to design (a) in Figure 3, are shown in Table 2. Simple chi-square tests did not show any significance of shape at the 0.05 level. However, a more complex Mantel-Haenszel test, that included the results from all combinations of colour, did indicate a significant difference between the results for a triangle compared to circle shaped central patch.

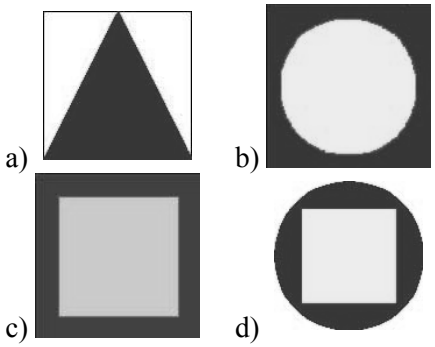

Figure 3: Examples of 50:50 area two-shape designs.

The pattern of the average values for P(Exc) in Table 2 is similar to that shown in Table 1, the green and blue showing lower values than the red and yellow. There is a significant difference in the response to the yellow, where against the grey background P(Exc) was 93% and against the white background P(Exc) was 58, almost neutral.

It is suggested that the visual contrast between the central colour and the surround colour may have a strong influence on the ***exciting- calming*** emotional response. Since the yellow on mid-grey design has a much higher visual contrast than the yellow on white design, the results suggest that a low level of visual contrast tends to move the emotional value towards the neutral (P(Exc)=50%).

Table 2: Number of "Exciting" judgments from 100 decisions on a 50:50 design of a coloured shape on a square shaped white background

	Circle	Square	Triangle	% P(Exc)
Red	87	85	83	85% ± 1(SE)
Yellow	64	60	50	58% ±4(SE)
Green	16	11	18	15% ±2(SE)
Blue	16	17	11	15% ±2(SE)

The central colour has a major influence on the response and the surround colour may provide a strong modifying effect. The influence of surround colour is clearly apparent by comparison of the results for 50:50 area designs shown in Table 3 with those in Table 2. A blue inner area on a white background was judged to have a P(Exc) of 15% (85% calming). Placing the blue area on a red surround resulted in an increase of P(Exc) to 55% (45% calming), which is almost emotionally neutral.

Table 3: Number of "Exciting" judgments from 100 decisions on a 50:50 design

Outer shape	Inner shape	Exciting
Red square	Blue circle	53
Red circle	Blue square	54
Red square	Blue square	57
Red square	Yellow circle	91
Red circle	Yellow square	86
Blue square	Red square	75

The influence of a red surround on the response to a yellow inner area was equally as strong. Placing the yellow area on a red surround instead of a white surround increased the shape-averaged exciting impression P(Exc) from 58% to 89%. The influence of the surround colour on the response to a red inner area was not as dramatic. Table 3 shows that placing the red area on a blue surround instead of on a white surround reduced the exciting impression P(Exc) from 85% to 75%.

The effect of the relative area of the surround to the inner area on the number of "exciting" judgements was studied using six designs. Against a white background, a yellow shape produced around 58 "exciting" judgements. Table 4 shows that using a red outer area increased the number of "exciting" judgments to 81 (25% red 75% yellow) and, when the area of red was raised to 75% (25% yellow), the number of "exciting" judgements increased to 91.

Table 4: Number of "Exciting" judgments from 100 decisions on designs of various relative areas

Outer area	Inner area	Exciting
Red 75%	Yellow 25%	88
Red 50%	Yellow 50%	91
Red 50%	Yellow 50%	86
Red 25%	Yellow 75%	81
Yellow 75%	Red 25%	92
Yellow 25%	Red 75%	95

A similar dependence of the number of "exciting" judgements on area was seen for designs with a red inner area and a yellow surround. Against a white background, a red shape produced around 85 "exciting" judgements, adding a yellow surround increased the number to over 90. For two designs with a red inner area and a yellow surround, it was observed that increasing the area of red from 25% to 74% increased the number of "exciting" decisions from 92 to 95 respectively, Table 4.

4. CONCLUSIONS

Studies of the observer response to simple designs with a central coloured shape on a coloured background have shown that the major factor determining the response was the colour of the central area. The colour of the background design had almost as strong an influence on the observer response, for example changing an almost neutral response (yellow on white background) to a nearly 90% "exciting response" (yellow on red background).

The relative area of the central shape to the background area was found to have a modest influence on the observer responses.

The shape of the central colour area (circle, triangle and square) had only a slight influence on the number of "exciting" decisions.

It is suggested that the visual contrast between the colour of the central shape and the colour of the background has a strong influence on the response of the observers.

It is concluded that there is limited value in applying colour emotion scales obtained from data sets of observer responses to single colours, to the prediction of the likely observer response to two colour, and more complex, designs.

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