

A COLOUR DISPLAY SYSTEM

Technical Field

This invention relates to a colour display system for aiding the selection and
5 combination of colours in colour scheming.

Background to the Invention and Prior Art

Consumers and professional specifiers alike sometimes have difficulty in quickly and
reliably identifying colour combinations that are likely to appeal to the human eye.
10 While those with particular aptitude will have the capability to use other aspects of an
interior design such as relative surface areas, texture and lighting to use virtually any
combination of colour to achieve attractive displays, most find some degree of
guidance in narrowing down the choice of alternatives helpful as long as the guidance
is not overly prescriptive. In the absence of such guidance and under pressure of
15 deadlines, colour schemers are more likely to repeat previous schemes, rather than
explore other potential combinations more suited to the task in question.

Various guides have been used to proposed colour schemes following the choice of an
initial key colour. The ICI Paints Colour and Contrast guide recommends colours
20 schemes based on the principles of the Colour wheel combined with maintaining
similar tonal purity for the proposed choices. The ICI Eye for Colour system also
measures a colour and then recommends a single contrasting hue and two
harmonising hues, each at a number of lightness values.

25 Colour wheels are a 2-dimensional representation of colours that have a fixed
relationship to colours with which they co-ordinate. Colours are represented in a
progression of hues around a circle. Usually only the most saturated colour available
is shown, but these very bright colours are only used infrequently for interior
decorating. Some wheels show other less saturated colours of the same hue in
30 progressively smaller segments towards the centre. However, these are generally
show only a few colours, typically 60, or use very small colour representations.

If it were possible to create a colour wheel that uses colours within a tonal zone rather
than the most saturated colour available, it would be much more useful as a practical

colour scheming tool. However, it is difficult to produce a colour display which relates colours of the same hue but different tonal purity zones.

5 Some improvement is offered by known colour grid systems. Such a system comprises a two-dimensional array of colour sample elements in the form of areas of colour coating on strips of card. The cards are arranged in blocks which are, in turn, arranged in a grid of horizontal rows and vertical columns. The colours of the colour elements, their arrangements on the strips, the arrangement of the strips and blocks are such that, typically, there is a progression of hue in one direction in the array and a
10 progression of tonal purity in an orthogonal direction. Such a system offers advantages over colour wheels since colour wheels make ineffective use of their coated surface area. The system also offers advantages over a computerised system in that a multiplicity of users can use the system simultaneously and colour reproduction can be controlled tightly. Such a system allows a large number of colour sample
15 elements to be viewed simultaneously and in an ordered arrangement. However, it has been found that unskilled users find the systems to be of limited use in selecting combinations of colours that appeal to the eye of the average person.

Summary of the Invention

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It is an object of the present invention to provide an instrument which allows unskilled users to select combinations of colours over a wide range of hues and tonal purity in a comparatively reliable way.

25 According to a first aspect of this invention, there is provided a colour display system for aiding the selection and combination of colours in colour scheming, wherein: the system comprises an array of colour sample elements each of a respective colour, the elements being grouped in discrete blocks according to hue, chromaticity and lightness; the colour sample elements of each block all have colours which are within
30 a hue range respective to that block and which have predetermined chromaticity and lightness properties associated with that block; the blocks are arranged in at least 3 parallel lines according to their associated chromaticity and lightness properties such that all of the blocks in each line have similar or the same respective associated chromaticity and lightness properties; each line contains M blocks (where $6 \leq M \leq 12$)

- which are arranged in a hue range sequence along the line; within each block the colour sample elements are arranged in a series of hue increments in the direction of the said lines and corresponding to the sequence of the hues of the elements in the visible spectrum, and in a series of lightness increments such that lightness increases
- 5 in the orthogonal direction; and the angular range of hues in each block, as defined by the CIELAB colour space, vary in size between blocks such that the blocks containing the 90 degrees CIELAB hue have a hue angle range of one half or less than one half the size of the hue angle range of the blocks containing the 270 degrees CIELAB hue. Preferably, the hue range sequence along each line corresponds to the sequence of the
- 10 hue ranges in the visible spectrum such that the array contains M parallel non-overlapping hue range segments in a direction orthogonal to the lines. In particular, it is preferred that the lines are horizontally oriented rows and the hue range segments comprise vertically oriented columns in the array.
- 15 In a particularly preferred embodiment, for any first block in any one of the rows, there is another, second, block which has a conformity of at least 75%, based on a reference colour wheel having n sectors of equal angle which map onto the CIELAB colour space as mapped sectors of unequal angles which, between a first angular range of 140 and 230 degrees Hue in the CIELAB colour space, have an average
- 20 subtended angle per sector of $(2 \pm 0.2)360/n$ degrees in the CIELAB colour space. The maximum angle subtended by any of the mapped sector of the CIELAB colour space is that of a sector lying between 150 and 220 degrees Hue.

In this specification the term "conformity" means a parameter quantifying the degree

25 to which elements of a first block of elements in an array of colour elements combine with elements of a second block of elements in the array, the parameter being as calculated in (a) and (b) below.

- (a) For each element i of the first block, count the elements of the second block
- 30 which have a hue within a predetermined angular deviation from the hue directly opposite that of the element i on a reference colour wheel.

(b) Sum the counts for all elements i of the first block and express the sum as a percentage of the total number of possible pairings of the elements i and the elements of the second block.

- 5 In the above preferred embodiment, there is a second angular range of between 78 and 98 degrees Hue in the CIELAB colour space in which the mapped sectors have an average subtended angle per sector of $(0.4 \pm 0.04)360/n$ degrees. Within this region, it is preferred that there is a slight maximum at or near 20 degrees Hue.
- 10 For a 48 step reference colour wheel, where the first step contains pure yellow (90 degrees Hue CIELAB), the third angular range includes steps 29 to 44 (corresponding to about five degrees to 70 degrees Hue CIELAB, with the maximum occurring in steps 31, 32 or 33 (i.e. between about 13 degrees and 27 degrees Hue CIELAB).
- 15 The remaining steps subtend angles having an average which is such that the total of all subtended angles of the mapped sectors sum to 360 degrees in the CIELAB colour space.

It is preferred, but not essential, that the hue angles subtended by the mapped sectors
20 vary progressively rather than in a series of discontinuities around the CIELAB colour space.

The number of sectors on the reference colour wheel, n , is advantageously an integer divisible by six and/or eight, and is at least six. One preferred value is 48.

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The number of blocks in each line is preferably seven or eight, with no more than two blocks encompassing a hue angle range of at least 140 degrees Hue in the CIELAB colour space, this range including the 255 degree and 313 degree CIELAB hues.

- 30 In one variant, the hue ranges of the individual blocks in each line are of equal angular extent on the reference colour wheel. In another variant, particularly applicable in the case where M is an odd number, the hue ranges of the individual blocks in each line are of unequal angular extent on the reference colour wheel with, e.g., the angular

extent of the hue range of one of the blocks of the line being at least 1.5 times the angular extent of the hue range of at least one of the other blocks of the line.

5 The applicants have found that the average person's perception of colour is such that they are particularly sensitive to and aware of differences in hue in the yellow region of the visible spectrum, especially when compared to, for instance, the green and blue regions when hues are measured against one of the established colour definition standards such as the CIELAB colour space. The observation that the average person tends to prefer contrasting colour combinations from opposing sectors of a colour
10 wheel is, in itself, of uncertain and, therefore, limited use in devising an improved aid to colour scheming because there are a number of different colour wheels. The system set out above takes account of these factors and other observations relating to how people react to different colour combinations in providing a particular arrangement of colour sample elements in an array is defined in terms of an
15 established colour measurement standard. The result is a reduction in the need for skill in achieving successful combinations over a wide range of colours. This is done while still providing the user with latitude in the selection process.

20 According to another aspect of the invention, there is provided a colour display system for aiding the selection and combination of colours in colour scheming, wherein: the system comprises an array of colour sample elements each of a respective colour, the elements being grouped in discrete blocks according to hue, chromaticity and lightness; the colour sample elements of each block all have colours which are within a hue range respective to that block and which have
25 predetermined chromaticity and lightness properties associated with that block; the blocks are arranged in at least 3 parallel lines according to their associated chromaticity and lightness properties such that all of the blocks in each line have similar or the same respective associated chromaticity and lightness properties; each line contains M blocks (where $6 \leq M \leq 12$) which are arranged in a hue range
30 sequence along the line; within each block the colour sample elements are arranged in a series of hue increments in the direction of the said lines and corresponding to the sequence of the hues of the elements in the visible spectrum, and in a series of lightness increments such that lightness increases in the orthogonal direction; the

system further comprises at least one guide device indicating the pairing of predetermined blocks in each line.

It is preferred that, in the systems described above, given that the blocks are arranged in at least 3 parallel lines, and the lightness and chromaticity properties of the colours of the colour sample elements in the at least 3 lines conform to the following conditions (i), (ii) and (iii) respectively:

(i) the colour is substantially fully saturated or is a mixture of the fully saturated colour and black;

(ii) the colour does not meet condition (i) and is a mixture of a saturated colour and a visibly significant level of white, but has no visibly significant level of black, for any given hue, the lightness being of higher than any colour in (i); and

(iii) the colour does not meet condition (i) nor condition (ii) but is in the group of colours that are mixtures dominated by grey, but contain a visibly significant level of saturated colour, and for any hue and lightness have a lower chromaticity than those colours of the same hue and lightness meeting conditions (i) and (ii).

The zone of colours meeting condition (iii) may be divided into, e.g., two groups of different chromaticities such that, in one group, the colours have a higher chromaticity than the colours of the same hue and lightness in the other group. In this case, the blocks are arranged in at least 4 parallel lines in the array.

In the preferred array, the colours falling under condition (i) may be termed "Vibrant", and those falling under condition (ii) may be termed "Fresh". Where the colours falling under (iii) are divided into two groups, those with higher chromaticity may be termed "Warm" and those with lower chromaticity "Calm".

The colours within each block may be arranged such that lightness increases consistently in one direction, and that hue increases consistently in an orthogonal direction. It is not essential that every available hue increment or slice is represented in each block, nor that all the hue increments represented in a block are equally

represented. However, it is desirable that the hue differences between hue slices within a block are less than 15 degrees. It is also preferred that within each hue increment at least two lightness levels are available and preferably four or more as this enables more choice of monochromatic schemes within a block.

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As noted above, there are a number of different reference colour wheels which may be used, and which each oppose acceptable contrasting colours in slightly different ways. In this specification we describe a particularly preferred transform which may be applied to the standard CIELAB colour wheel to produce a particular reference colour wheel which is used by the described embodiments, but in other embodiments any other reference colour wheel which opposes acceptable contrasting colours in other ways may be used. However, whatever reference colour wheel is used as the basis for a colour display array according to the invention, in embodiments of the invention it is possible to apply the principle of conformity as described above to select colours for the colour sample elements in each group which will provide a predetermined conformity. The conformity parameter is a measure of how well a colour display array will be able to facilitate easy selection of acceptable contrasting colours for a particular reference colour wheel, with a higher conformity value indicating that the array will be able to more easily facilitate contrasting colour selection. In accordance with a further aspect of the invention, therefore, there is also provided a colour display system for aiding the selection and combination of colours in colour scheming, wherein:

the system comprises an array of colour sample elements each of a respective colour, the elements being grouped in discrete blocks according to hue, chromaticity and lightness;

the colour sample elements of each block all have colours which are within a hue range respective to that block and which have predetermined chromaticity and lightness properties associated with that block;

the blocks are arranged in at least 3 parallel lines according to their associated chromaticity and lightness properties such that all of the blocks in each line have similar or the same respective associated chromaticity and lightness properties;

each line contains M blocks (where $6 \leq M \leq 12$) which are arranged in a hue range sequence along the line;

within each block the colour sample elements are arranged in a series of hue increments in the direction of the said lines and corresponding to the sequence of their hues angles in a reference colour space which opposes generally acceptable contrasting hues, and in a series of lightness increments such that lightness increases
5 in the orthogonal direction; and

the angular range of hues in each block, as defined by the reference colour space, being selected to provide a predetermined conformity, wherein the term "conformity" means a parameter quantifying the degree to which elements of a one said group of colour sample elements in the array combine with elements of another
10 group of elements in the array, the parameter being calculated (a) by counting, for each element i of the one group, the elements of the other group which have a hue within a predetermined angular deviation from the hue directly opposite that of the element i on a reference colour wheel, and (b) by summing the counts of all elements i of the one group and expressing the sum as a percentage of the total number of
15 possible pairings of the elements i and the elements of the other group.

Another aspect of the invention provides a method of colour scheming comprising selecting and combining colours from an array of colour sample elements each of a respective colour, wherein:

the colours are grouped in the array into discrete groups according to hue,
20 chromaticity and lightness;

the colour sample elements of each group all have colours which are within a hue range respective to that group and which have predetermined chromaticity and lightness properties associated with that group;

the groups are arranged in at least 3 zones according to their associated
25 chromaticity and lightness properties such that all of the groups in each zone have similar or the same respective associated chromaticity and lightness properties;

each zone contains M groups (where $6 \leq M \leq 12$) which are arranged in a hue range sequence;

within each group the colour sample elements are arranged in a series of hue
30 increments and in a sequence corresponding to the sequence of their hues angles in a reference colour space which opposes generally acceptable contrasting hues, and in a series of lightness increments such the elements in each group form a matrix in which hue varies in one direction and lightness varies in an orthogonal direction; and

the angular range of hues in each block, as defined by the reference colour space, being selected to provide a predetermined conformity, wherein the term "conformity" means a parameter quantifying the degree to which elements of a one said group of colour sample elements in the array combine with elements of another group of elements in the array, the parameter being calculated (a) by counting, for each element *i* of the one group, the elements of the other group which have a hue within a predetermined angular deviation from the hue directly opposite that of the element *i* on a reference colour wheel, and (b) by summing the counts of all elements *i* of the one group and expressing the sum as a percentage of the total number of possible pairings of the elements *i* and the elements of the other group.

Here, "oppose" means having two hues which are generally thought to artistically contrast well with each other arranged on a reference colour wheel such that the hues are opposite each other on the wheel, substantially 180 degrees apart.

Others aspects of the invention include design processes, decorating and colour scheming methods, collections of coloured items brought together and retail spaces out in accordance with the principles set out herein. In particular, they include an interior or exterior design process as set out in claim 21 hereinafter, a method of decorating interior or exterior surfaces of a building, as set out in claim 24, a method of colour scheming as set out in claim 25, a collection of coloured items as set out in claim 28, and a retail space as set out in claim 30.

Coloured items here include, for example, coving, wall coverings, paving slabs, tiles, floor coverings (including carpets), fabrics (particularly furnishing fabrics and curtains), furniture, soft furnishings and blinds.

Reference is made here to "paint" and to "painting". The term here is used broadly to include coatings, in particular paints, varnishes and lacquers, and their application. These coatings can be ready-made or produced from tinting systems in-store. A collection of tinters produced according to the principles of this invention is also included within its scope.

Description of the Drawings

The invention will now be described by way of example with reference to the drawings in which:

5 Figure 1 is a front view of a display system in accordance with the invention;

Figure 2 is a diagram illustrating the CIELAB colour space coordinate system;

10 Figures 3A and 3B are graphs representing the transformation between CIELAB colour space and the hue steps of a reference colour wheel upon which the distribution of hues in the display system of Figure 1 is based;

Figure 4 is a graph plotting hue angle against colour card number for a first example array;

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Figure 5 is a graph plotting hue angle against colour card number for a second example array;

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Figure 6 is a graph plotting hue angle against colour card number for a third example array;

Figure 7 is a graph plotting hue angle against colour card number for a fourth example array; and

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Figure 8 is a graph plotting hue angle against colour card number for a fifth example array.

Description of the Embodiments

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A colour display system in accordance with the invention for aiding the selection and combination of colours in colour scheming comprises a two dimensional array 10 of colour sample elements 12 which are each of a respective colour. In the example illustrated in Figure 1, there are 1386 colour sample elements 12. These are grouped in 28 discrete blocks according to hue, chromaticity and lightness. The colour sample

elements 12 of each block 14 all have colours which are within a hue range respective to that block and which have predetermined chromaticity and lightness properties associated with that block 14. The blocks 14 are arranged in 4 parallel rows 16 according to their associated chromaticity and lightness properties such that all the
5 blocks 14 in each row 16 have similar or the same respective associated chromaticity and lightness properties.

In this example, each row 16 contains seven blocks 14 which are arranged in a hue range sequence along the row 16, extending from a first block 14A at one end of the
10 row containing elements based on red hues through to a seventh block 14G at the other end of the row, containing elements based on violet hues. The blocks 14B to 14F between the two end blocks 14A, 14G have elements based respectively on orange, gold, yellow, green and blue hues, arranged in the order in which these hues appear in the visible spectrum.

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As a result, the array 10 of colour sample elements contains seven parallel non-overlapping hue range segments 18A to 18G, each running in a direction orthogonal to the four rows 16, and appearing as vertical columns in the array 10.

20 It is to be understood that the display system shown in Figure 1 does not consist solely of the array 10 of 28 blocks 14 arranged as described above. The system also includes an auxiliary array 20 of four blocks containing colour sample elements of neutral colours, arranged as a group of blocks extending in the vertical direction. Accordingly, references to the colour sample elements and blocks above are
25 references to elements and blocks of the first-mentioned array 10 alone, and do not include the elements and blocks of the auxiliary array 20.

Within each block 14A to 14G of the array 10, the colour sample elements 12 are arranged in a series of hue increments in the direction of the rows 16, the increments
30 being arranged in a hue sequence corresponding to the hue sequence of the hues in the visible spectrum, and in a series of lightness increments (i.e. lightness) such that lightness increases in a downward vertical direction within each block. It follows that in the array 10 as a whole, the colour sample elements 12 produce a progressive change of hue in accordance with the visible spectrum in the horizontal direction. In

the vertical direction, the juxtaposition of the lightest elements along the bottom line of each of the three uppermost rows with the darkest elements, respectively, of the blocks below serves to emphasise the divisions of the array into rows. The boundaries between the blocks 14A to 14G in each row are emphasized by guide cards 22 placed
5 between the blocks, each illustrating an example of colour scheming using colours from the adjacent block.

Accordingly, the array comprises a number of colour elements 12 in which each colour appears only once in the array and the range of colours used is spread
10 throughout the colour space, e.g. the colour space defined by the known CIELAB colour space in which hues are defined as angles in a cylindrical co-ordinate system. In general terms, different numbers of colour elements may be used, typically between 600 and 2000. As explained above, the sample elements are divided into blocks 14 and, as will be seen from Figure 1, the blocks 14 are arranged in a grid
15 pattern. Within each block, the elements themselves are arranged in a grid pattern. As will be explained below, the position of the blocks, and the boundaries of the blocks in colour space produce certain properties in the arrangement of colour sample elements that allow the system to be used as a colour guide to assist colour scheming choices. In particular, the system allows users to focus on a selection of colours that
20 co-ordinate well with an initial selected colour. This choice may be performed in a series of steps from an initial grouping of between 150 and 500 colours, down to a group of 50 to 100 colours. This is achieved by dividing the colour space into subsets of colour space of colours or zones, as exemplified by the rows 16. Colours are assigned to particular zones according to the relationship between chromaticity as a
25 function of Y value, compared to the chromaticity and Y value of the most chromatic colour of that hue which can be typically reproduced.

These zones of colours are further subdivided into smaller subsets, which are the blocks 14A to 14G. Colours are assigned to a particular block within a zone,
30 dependent on their hue. The blocks 14A to 14G are then arranged in a two dimensional array such that the allocation of each block is determined by the zone, and by the hue range of the block. Owing to this arrangement of the blocks, each block can be related to another block in a simple way to allow selection of colours which co-ordinate attractively. This selection can be particularly successfully

achieved by choosing the angular ranges of the hues in each block in a manner described below and by arranging for the blocks to meet particular statistical criteria (hereinafter referred to as "conformity") based on a predetermined reference colour wheel.

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Colour scheming may therefore be based on interrelated blocks within the array 10 based on principles that involve a geometrical relationship between an ideal combination and actual position (even for cases where the number of blocks 14 per zone to row 16 is odd). If the number of blocks per zone is odd, as in the case of the embodiment described above with reference to Figure 1, the array is particularly easy and intuitive to use, because an uneven distribution of hue increments from one block 14 to another allows simple and familiar terms to be used in instructing the user. The specific version described above with reference to Figure 1 allows an optimum number of colours per block 14 to facilitate colour scheming.

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The blocks 14 are separated from other blocks 14 by a space or a line within the array 10, allowing guidance as to the use of the system to be located between the blocks, as described above, in the form of, for instance, colour scheming guide cards 22.

20 Within each block, the colour sample elements are on strips of card oriented vertically alongside each other in the block. The cards may be removed for comparison against articles and other colour sample elements. Each strip preferably contains colour sample elements 12 of only one hue increment.

25 The two dimensional array 10 may be presented to the observer horizontally for use on a desk top, or as a vertical arrangement to be viewed from a standing position. The latter is preferred because it offers scope for larger colour representations.

30 The blocks 14 of colour sample elements 12 correspond to irregular polygons in colour space defined in mathematical form as boundaries made up of curves defined in terms of lightness, and chromaticity for a small angular range of Hue angle, and a Hue Segment bounded by a maximum and minimum hue. The manner in which the boundaries are set determines the usefulness of the array as a guide to colour co-ordination.

Two factors are used to determine the boundaries. One factor relates to hue, and the way that hues may be combined to form the most attractive combinations in interior decoration. The other factor relates to lightness, chromaticity and the relationship
5 between them, and how colours of similar tonal purity combine to form colour schemes. Applying both of these factors simultaneously to form an arrangement of colours in blocks allows users to focus their attention on a manageable group of colours while also enabling them explore a large number of potential colour combinations.

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It is appropriate at this point to give some initial definitions. Hue is the quality of a colour that we describe as the colour of the rainbow or visible spectrum, that is, the property of the colour that is independent of lightness or chromaticity.

15 In CIELAB colour space, colours are defined by cylindrical co-ordinates. Thus, referring to Figure 2, the Hue Angle defines the hue component as the angular co-ordinate in a polar co-ordinate system around an achromatic lightness or reflectance axis Y or L , where zero degrees Hue is the a axis. In practice, zero degrees Hue in the CIELAB colour space corresponds approximately to the colour magenta. As hue
20 angle increases, the hues pass through red, orange, yellow (at 90 degrees Hue also the b axis), green, turquoise, blue and violet, the violet region extending to 360 degrees Hue which corresponds to zero degrees Hue, forming the complete hue circle.

It will now be appreciated that a hue slice in colour space is a sector of colour space,
25 containing colours of various undefined lightness and chromaticity, but within narrow angular ranges of hue. In this description, the slice subtends a hue angle of between 5 and 15 degrees.

At the centre of the CIELAB colour space, where Y equals zero, is the colour black.
30 Lightness increases along the axis Y and chromaticity increases radially outwardly from the axis Y to a maximum at the circumference of the hue circle, as shown in Figure 2. Accordingly, any colour within the array 10 (Figure 1) can be defined against the international standard represented by the CIELAB colour space. A

technique by which colours can be measured and, therefore, defined in the CIELAB colour space is set out in Appendix A hereto.

Each block 14 in the array 10 is made up of a series of equivalent colour zones
5 corresponding to the rows 16 which form annular spaces around the Y axis of colour space, through consecutive hue slices.

It will be understood from the above that, within a hue slice, colour space can be divided into a number of zones, such that the differences between these zones within
10 the same hue slice relate to the depth and greyness of the colours contained within the zones. It has been found that if colour space is divided into hue slices, and that all of the hue slices are then divided into zones using the method described, colours from a single zone or equivalent zones, of whatever hue, look attractive together. This has been demonstrated in colour displays that group a wide selection of colours within a
15 zone, in horizontal bands, where hue progresses from one end of the display to another.

In the array described above, the hues are grouped into the blocks 14 within each zone, and hue blocks are separated from neighbouring hue blocks within the same
20 zone by a clearly visible space containing instructions on the use of the guide. The purpose of the space or line is to make it clear that the blocks are separate from each other.

Blocks containing colours within similar hue ranges but in different zones are
25 distinguishably different because either they are separated by a space or line or because of a sharp contrast in lightness, in an arrangement where lightness increases or decreases in a direction orthogonal to the hue progression.

Colours within each zone are separated into the hue blocks 14 in a similar manner, so
30 that once a hue block 14 has been identified in one zone as having a specific hue range, blocks 14 consisting of the same hue range can be identified in each of the other zones.

The blocks 14 are arranged in a grid such that in one moving from block to block in one direction allows the user to find similar colours that are contained within the same zone but are different in hue, while moving from block to block in an orthogonal direction allows to user to find colours within that hue range but having different
5 lightness and/or chromaticity characteristics.

Colour scheming may be performed, firstly, within a block 14. When the hue slices are also grouped using the manner described, into recommended hue bands, blocks of colours are formed such that any two or more colours selected from within that block
10 co-ordinate well together in either a monochromatic or harmonious colour scheme.

The colours within a block contain a range of lightness and chromaticity values, consistent with its zone. In the preferred embodiment, the majority of the blocks 14 have 54 colour sample elements 12. In one row, there are 36 elements 12. In general
15 terms, the blocks of arrays used in systems in accordance with the invention contain between 20 and 100 colour sample elements, and preferably more than 48 elements.

Colour scheming between the blocks is based on a property of the described system which is that for each block 14, there will be a corresponding opposing block 14 in the
20 same zone or row 16 such that the vast majority of colours from the first block form very good combinations based on contrasting and split colour schemes when used with the vast majority of colours from the opposing block. For example, if a colour is selected from one of the yellow blocks 14D, the vast majority of colours in the violet block 14G in the same row 16 form a good combination with the yellow colour. The
25 same will be true of any colour selected from the yellow block in question. Similar pairings are achieved between other blocks in each row, based on the fact that the distribution of hues horizontally in the array 10 is a transformation of the distribution of hues around a predetermined reference colour wheel. Thus, given that research has shown that good contrasting and split colour schemes arise by choosing colours from
30 opposing sectors of the predetermined reference colour wheel, corresponding pairings of blocks can be used in the manner just described to produce successful combinations.

To illustrate in more detail how colour scheming may be performed in the manner summarised above, three stepwise processes are now described.

(a) Finding the Nearest Colour

- 5 Step 1: Identify by visual inspection the column 18A – 18G blocks 14A – 14G having the same broadly general hue as a key colour. This narrows the number of colours from 1386 down to about 200. (In general terms, other embodiments of the invention result in a reduction from between 50 to 200 down to 80 to 200.)
- 10 Step 2: From the group of blocks identified in Step 1, identify by visual inspection the block that has similar tonal purity to the key colour. This block will contains 36 or 54 elements 24-100) in the general case.
- 15 Step 3: By visual inspection, scanning horizontally along the row of the more chromatic colours within the block selected in step 2, identify the colours of similar hue to the key colour. Typically this subset of the colours within the block contains a group of 4-18 colours.
- 20 Step 4: By visual inspection scanning vertically the subset of colours identified in Step 3, identify from colour or group of colours of the nearest lightness. Typically this identifies 1-3 colours.

- 25 Step 5: By visual inspection identify the colour of nearest chromaticity, lightness and hue to the original colours from the small group identified in step 4.

(b) Identifying other colours with which to co-ordinate

- 30 Step 6: Examine the row of blocks indicated as containing elements of the same tonal zone as the block selected in step 2. This group of typically 150 to 500 elements will go well with the key control elements.
- Step 7: Examine the elements within the block identified in Step 2. This group of typically 24 to 100 colours will co-ordinate particularly well with the original colour, forming either monochromatic or harmonising colour schemes.

Step 8: Identify and locate the opposing block using guidance given in a guide text grouping blocks in pairs. The colours within this block will co-ordinate particularly well with the original colour in the block identified in Step 2 in contrasting or split colour schemes. Typically this represents 24-100 colours

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(c) Alternative Steps

When the user of the guide has a general idea of the colour they wish to use rather than a specific identified colour, the following steps are appropriate.

- 10 Step 1: Identify the block of elements most representing the area of colours envisaged as forming a basis for a particular colour scheme.

- Step 2: Examine the elements within the block identified in the previous step. This group of typically 24 to 100 colours will co-ordinate particularly well with any other
15 colour in the group forming either a monochromatic or harmonising colour schemes.

Step 3: Identify and locate the opposing block using the guidance given in the guide text.

- 20 The colours within this block will co-ordinate particularly well with the colours in the block identified in the previous step in contrasting or split colour schemes.

- As stated above, the rows 16 each represent a particular zone in colour space, with respective chromaticity and lightness characteristics. These are explained in more
25 detail below with reference to Figure 1.

Zone 16-1 (Vibrant)

- Within each hue slice this zone contains strong colours, including colours of maximum saturation for that hue, colours close to that colour, and colours that are
30 mixtures of the maximum saturation colours for that hue, and black (i.e., "shades"). Colours that are virtually achromatic with very little white are generally rated Vibrant (Black is Vibrant); however, the boundary varies with hue. Colours falling into this zone according to its associated criteria are classed as Vibrant and are excluded from

the other zones even if they meet the criteria associated with those other zones. Accordingly, the Vibrant criteria override those of the other zones.

5

Zone 16-2 (Fresh)

This zone contains colours that are close to the maximum saturation available at that lightness level, but that are lighter than the most saturated colour available at that hue. Such colours are sometimes referred to as “tints”. Accordingly, if the chromaticity is
10 above a maximum value calculated for the lightness and hue in question, the colour lies in this zone unless it meets the overriding criteria of zone 16-1.

Zone 16-3 (Warm)

This zone contains colours that are not contained within the other zones 16-1, 16-2,
15 16-4. They are intermediate in chromaticity at a given lightness. It follows that if the chromaticity is above a minimum value for zone 16-4, and below the maximum chromaticity value referred to above in connection with zone 16-2, the colour will lie in the Warm zone unless its parameters fall within the overriding criteria for zone 16-1 (Vibrant).

20

Zone 16-4 (Calm)

In this zone, colours have low chromaticity for their lightness level but are not necessarily achromatic, but does not contain the very deepest low saturation colours that have very little or no white content. In other words, if the chromaticity of a colour
25 is below a minimum value calculated for its lightness and hue, the colour will lie in this calm zone unless its rated Vibrant according to the overriding criteria (lacking white) referred to above.

The colours in the Warm and Calm zones may be referred to as “tones”.

30

In other embodiments, it is possible to subdivide the above zones on the basis of lightness of chromaticity or both, as long as this is done within each hue slice or segment in a consistent fashion. However, dividing the array into more than six zones or rows reduces the number of potential colour schemes identified by the system.

Division of the array 10 into hue segments 18 is now considered. These segments preferably form the hue boundaries of the blocks 14, but it is conceivable within the scope of the invention for different blocks 14 in different rows 16 to have different hue boundaries.

The hue boundaries of the blocks 14 are defined in terms of Hue Steps on a reference colour wheel using the following method. Although it is not essential that the hue boundaries are the same across all the lightness and chromaticity zones, it is preferred that they are because it allows the user of the guide to locate any given colour more quickly within the array. (A transformation from Hue angles in CIELAB space to the Hue Steps referred to above is performed because the CIELAB hue circle does not represent an appropriate basis for reliable colour combination.)

The hue increments of the array may map onto the hue steps of the reference colour wheel linearly or non-linearly. In the array of Figure 1 there are 63 hue increments and 22 colour sample elements per increment. (In the general case there may be 12 to 150 elements per increment.) They are grouped into blocks of the array so as to meet "conformity" criteria, as will be explained in more detail below. Within each block the hue increments may be distributed evenly or unevenly in terms of their distribution on the reference colour wheel.

For the purpose of defining the hue boundaries of the blocks, the reference colour wheel is divided into an even number n of sectors such that when the most saturated colours available of each hue are arranged in order of hue equidistantly around the circumference of a circle (the reference colour wheel), colours lying opposite each other form the best contrasting colour combination and the difference in hue angle between any two adjacent colours on the circumference is no more than $1.5 \times 360/n$ degrees Hue. n may be divisible by 6 or 8, preferably both, giving a preferred value of 48.

The Hues chosen include pure yellow, that is the most saturated colour having a CIELAB Hue angle between 88 degrees and 92 degrees.

The ranges of hues included in the i th Hue Step (on the reference colour wheel) corresponding to the i th colour around the wheel are determined as follows, H_i being the i th hue of the wheel expressed in degrees, where $1 \leq i \leq n$.

- 5 For the apparent discontinuity where H_i is the colour on the circle of lowest hue, given that $\text{Hue} + 360 = \text{Hue}$ when Hue angle is expressed in degrees.

$$0.5*(H_i + H_{i-1} - 360) \leq \text{Hue} < 0.5*(H_i + H_{i+1}) \text{ where } H_{i+1} > H_i$$

- 10 For the other colours

$$0.5*(H_i + H_{i-1}) \leq \text{Hue} < 0.5*(H_i + H_{i+1}) \text{ where } H_{i+1} > H_i \text{ and } 1 < i < n,$$

$$0.5*(H_1 + H_n) \leq \text{Hue}_1 < 0.5*(H_1 + H_2) \text{ where } H_{i+1} > H_i, \text{ and}$$

15

$$0.5*(H_n + H_{(n-1)}) \leq \text{Hue}_n < 0.5*(H_n + H_1) \text{ where } H_{i+1} > H_i,$$

On the reference colour wheel:

- 20 Hue step 1 corresponds to Hue range encompassing the position on the circle of pure yellow;

Hue step 2 corresponds to the Hue range immediately adjacent Hue step 1, in the direction of increasing Hue; and

25

Hue Step n corresponds to the Hue range immediately adjacent Hue step 1, in the direction of decreasing Hue.

- 30 In order to offer sufficient variety of colour type within a block, M , the number of blocks per block type, ≤ 12 , but also to work well as a colour guide, $M \geq 6$.

It will be recalled that where N is the number of Hue steps in the colour wheel and M is the number of blocks per zone. In the system described above with reference to

Figure 1, M equals 7. For simplicity of explanation, however, it is assumed, firstly, that M is an even number.

In the above analysis, I represents the number of any given hue step around the reference colour wheel, in the following analysis, j is the number of any given block
5 14 along the array 10. Thus, we designate $d(j)$ as the number of hue steps in each block. When M is an even number, $d(j) = n/M$.

At this stage, it is assumed that the blocks in the array 10 are evenly distributed around the reference colour wheel. In practice, this is not usually the case when M is an odd number.

It is preferred that n and M are chosen such that n/M is an integer, but this is not essential.

15 Consider the following conditions:

For $j=1$, where $D + (n/M) \leq (n+1)$

The block contains Hue Step Min($j=1$), Hue Step Max($j=1$) and all hue steps in between. Here,

20 Hue Step Min(j) = $D+1$

Hue Step Max (j) = Hue Step Min(j) + $d(j) - 1$

For $j=1$ where $D + d(j) > N$

25 Here, there is a discontinuity since the block contains the Maximum Hue Step N. So for that block:

Hue Step Min(j) = 1; and

Hue Step Max(j) = N

but hue steps within the range D to $(D - n + d(j))$ are excluded

30

For the j th Block, where $j > 1$ and Hue Step Max($j-1$) $\leq n - d(j) - 2$

The block contains Hue Step Min(j), Hue Step Max(j) and all hue steps in between

Hue step $\text{Min}(j) = \text{Hue Step Max}(j-1) + 1$; and

Hue Step $\text{Max}(j) = \text{Hue Step Min}(j) + d(j) - 1$

- 5 For the j th Block, where $j > 1$ and $\text{Hue Step Max}(j-1) > n - d(j) - 2$, there is a discontinuity since the block contains the Maximum Hue Step n . So for that block:

Hue Step $\text{min}(j) = 1$; Hue step $\text{max}(j) = n$; but hue steps within the range Hue step $\text{max}(j-1)$ to Hue Step $\text{Max}(j-1) + d(j) - n$ are excluded.

- 10 For example, if $n = 48$, and $M = 8$, $n/M = 6$, and if the position of pure yellow in the array is defined by D , and $D = 23$, then:

$j=1$ contains hue steps 29 to 34 inclusive

$j=2$ contains hue steps 35 to 40 inclusive

$j=3$ contains hue steps 41 to 46 inclusive

- 15 $j=4$ contains hue steps 47 and 48 inclusive

and also hue steps 1 to 4 ($4 < \text{excluded steps} < 47$)

$j=5$ contains hue steps 5 to 10 inclusive

$j=6$ contains hue steps 11 to 16 inclusive

$j=7$ contains hue steps 17 to 22 inclusive

- 20 $j=8$ contains hue steps 23 to 28 inclusive

so for that example, Hue step 1, the hue step containing pure yellow is found in block 4.

25 Preferred values of D where M is even

It is preferred that D is chosen so that hue step 1 does not appear at the edge of a block, and is ideally situated close to the centre of a block. It is also preferred that D is chosen such that it does not appear in Block 1 or Block M . It is also preferred that the block opposing the block containing pure yellow does not form block 1 or block

30 M . This is because colours in the block containing yellow are generally frequently specified

Preferred value for M

Where M is even, the opposing block is fully aligned, and easily identified where $J \geq M/2$, the opposing block is simply $J + M/2$, where $J > M/2$, the opposing block is simply $j - M/2$.

5

The reference colour wheel is selected to reflect the average person's impressions as to which colour combinations represent successful colour schemes, based on research and observation using hues from the complete visible spectrum. The mapping of the hue steps of the reference colour wheel into CIELAB hue angles is shown in Figures 3A and 3B. Generalisations of the transformation represented by these curves are contained hereinabove and in the claims.

10

15

Using a selected reference colour wheel, colours having a hue with a given hue angle may, according to research and observation, be successfully matched in a contrasting or split colour scheme with colours whose hues lie within a sector of the reference colour wheel located generally oppositely (i.e. centred on a 180 degree opposite location) on the wheel.

20

It has been found that if the reference colour wheel is divided into M sectors, where M is at least 6 and no more than 12, it is possible to select a colour of any single hue within one sector and combine it with colours of any hue from the opposing sector on the wheel to obtain an acceptable combination with a high degree of probability. This probability can be expressed as a "conformity" calculated as follows:-

25

(i) For each hue step i of a first sector of the reference colour wheel, count the hue steps of a second sector, which is in a generally opposing position on the wheel, which have a hue within a predetermined angular deviation from the hue directly opposite of the hue step i on the wheel.

30

(ii) Sum the counts for all hue steps i for the first sector and express the sum as a percentage of the total number of possible pairings of the hue steps i of the first sector and the hue steps of the second sector.

The preferred angular deviation is ± 30 degrees on the reference colour wheel. Alternative deviations are possible, e.g. ± 20 degrees or ± 45 degrees, depending on the closeness of the match required.

- 5 It will be appreciated that the higher the value of M (the number of sectors), the higher the value of the conformity. If M is too high, each sector contains relatively few hues, with the result that the number of hues available to the user is too small.

10 It will be appreciated from the above that "conformity" can be used in the selection of M.

A value of 12 allows a very high degree of conformity, since all colours within a block or sector fall within one zone, and are within $n/12$ hue steps. Also, all colours in a sector or block J will fall within $5n/12 - 7n/12$ hue steps of the initially selected
15 hue step, ensuring contrasting and split colour schemes.

Too many colours in the array 10 prevent the system being a practical size or having colour representations of adequate size. An array containing 4 zone types and 12 blocks per zone type, provides a total of 48 blocks. If the colour range reproduced
20 contains 480 colours, this will only permit 10 colours per block. Even if 1200 colours are displayed, there will be only 25 colours per block. It is therefore beneficial to have fewer blocks, as the vast majority of colours still meet the criteria of combinations shown in the 12 hue block per row array.

- 25 Another reason for reducing the number of blocks is that it allows a greater variety of harmonious colour schemes within the block.

In addition, having fewer blocks allows the user to identify immediately colour groupings with simple colour terms such as red, orange, green, and so on.
30

Experimentation has shown that at least 6 blocks are required per zone for the guide to operate, and at least three zones.

As stated above, the array may have an odd number of blocks per row/zone.

Experimentation with a system in which M is odd using the principles of described above has shown that the proportion of colours that produce acceptable colour schemes is good as long as $M \geq 6$, but identifying the opposing block is much more
 5 difficult, and even when identified, the number of colours conforming was worse than expected. For example a model of a 7 block per zone system showed a percentage conformity of about 65%, compared to a 6 block system of over 80%.

Further experimentation with mathematical models of the system reveals that by using
 10 blocks of unequal size on the reference colour wheel, levels of conformity can rise to over 80% in particular if one block contains, e.g. twice the number of the steps of the two blocks most closely opposing the largest block, and the other blocks contain equal hue step ranges to each other. Depending on the required degree of certainty in matching, different conformity thresholds can be specified e.g. 60%, 65%, 70%, 75%,
 15 80%, 85%, 90% or 95% in constructing the array.

If K is the particular block chosen to contain most hue steps; if $d(j=K) = 2x$; if $3 < x < N/M$; and it is preferred that x is an integer, then:

20 Where $K < (M+1)/2$,
 $d(j=K+(M-1)/2) = x$, and
 $d(j=K+(M+1)/2) = x$
 for all other values of j , $d(j) = (n - 4X)/(M-3)$

25 Where $K > (M+1)/2$
 $d(j=K-(M-1)/2) = x$, and
 $d(j=K-(M+1)/2) = x$
 for all other values of j , $d(j) = (n - 4X)/(M-3)$

30 Where $K = (M+1)/2$,
 $d(j=1) = x$, and
 $d(j=M) = x$
 for all other values of j , $d(j) = (n - 4X)/(M-3)$

Once this step has been completed, the hue step ranges for each block can be calculated as before, but using the variable value of (j).

- It is, therefore, possible to use an odd number of blocks while still achieving a high level of conformity. Conversely, using such a degree of variation with an even number of blocks was found to produce lower levels of conformity, than using equal blocks.

for 1200 colours in 4 zones	No of Blocks per zone	% conformity	% conformity
Average Colours per block		Equal	Unequal
50	6	81	77
43	7	69	81
38	8	94	85
33	9	80	94
25	12	100	

- Unequal blocks are of special interest where the colour popularity in one hue area is very different from that in another, or where one hue area exhibits a very rapid transition in terminology, owing to the average persons' greater sensitivity to and awareness of hue differences in the corresponding part of the reference colour wheel. For example, hues that are relatively close to yellow are termed green or orange, whereas hues close to pure blue are still termed as blue.

Therefore, an array based on an odd number of colour blocks, where the colour block containing pure yellow has a hue step range approximately half of the hue step range of the block most nearly opposing it, tends to be more easily understood and more useful, even though arrays based on even numbers of blocks are easier to form.

So for example, where Hue step Y is pure yellow and 48 hue steps are used to form the reference colour wheel, Hue Step Y-3 can be orange, hue step Y-2 red toned

yellow, hue step Y-1 Yellow, hue Step Y Yellow, hue Step Y+1 Yellow, hue step Y+2 green toned yellow, and hue step Y+3 lime green.

5 Conversely, in the green area, the colours recognised as green extend over 9 or 10 hue steps, partly because blue/greens are generally described in terms of green or blue rather than as a separate universally recognised colour area. Even though the allocation of the hue steps to hue angles can partly rectify this issue, attempting to allocate too many hue steps in the yellow area distorts the relationships of the colour wheel in other areas.

10

Using fewer blocks is preferred for increased colour choice within a block, but more blocks allows higher degrees of conformity. Similarly, more zones allows tighter restriction on tonal purity. The presence of at least four tonal zones in the array has been found to allow good colour schemes to be generated from an array having >80%
15 conformity.

Specific examples illustrating the selection of colours for blocks of arrays according to further embodiments of the invention will now be described. The specific examples illustrate that many different specific layouts in terms of the number of blocks, the
20 number of stripe cards in each block and the colours chosen for each stripe card can produce an array which meets a chosen conformity characteristic. Particularly, the examples will show that a relatively high conformity value of > 80% can be achieved with several different layouts.

25 Example 1

In the arrangement of Example 1 to be described first, an array is provided having rows (referred to interchangeably below as "rows" or "zones") of stripe cards arranged in blocks (referred to interchangeably below as "sectors" or "blocks") as previously described, but where the numbers of stripe cards in each sector is not equal
30 to the split of the colour wheel steps. In particular, the number of colour wheel steps on the reference colour wheel is 48 as previously described, but the total number of stripe cards is 45. The reference colour wheel used in this and the following examples is the reference colour wheel described previously.

Sector	Cards	Colour Wheel steps	Hue at start	Step at start	Step at end
R	6	7	346	27	33
O	6	7	29.32	34	40
Go	6	5	61.14	41	45
Y	5	5	82.28	46	2
G	8	7	97.89	3	9
B	7	7	166.59	10	16
V	7	10	256.6	17	26

- The table above sets out the number of stripe cards in the array of Example 1 to be described, and in which blocks they are disposed. In particular, for each row of the array 7 blocks of stripe cards are provided, having the following colours: reds (R), oranges (O), golds (Go), yellows (Y), greens (G), blues (B), and violets (V), in that order from the left of the array. The second column of the table indicates the number of cards in each block (e.g. the gold block has 6 cards), and the third column the number of steps on the reference colour wheel over which the colours in that block are spread (e.g. the colours in the violet block are spread over 10 steps of the reference colour wheel). The fourth column gives the hue angle with reference to the CIELAB colour wheel (note, not the reference colour wheel) of the starting angle of the sector of the CIELAB wheel covered by the block (here, the "starting angle" is the most anti-clockwise boundary of the sector), and the fifth column gives the starting step on the reference colour wheel of the sector of the reference colour wheel covered by the block. Finally, the last column gives the finishing step of the reference colour wheel for each sector. Note that the reference wheel colour sectors for each block are inclusive of the starting and finishing steps shown in the fifth and sixth columns, as well as all steps in between.
- The above table relates to each row in the array of Example 1, for the reason that in example 1 a block in the same column but a different row (or zone) contains colours of the same hue range as another block in the same column, but with different luminance and chrominance values. As explained previously, luminance and chrominance changes can produce different zones of colours with different tonal properties but the same hue. The tables below set out the hue, chrominance, and luminance values of the colours on the left most stripe card and the right most stripe card in each block, for each zone. It should be understood that the colours present on

other stripe cards in a block would possess hue, luminance and chrominance values within the ranges established by the shown values.

Moreover, within the below tables, the hue values given are hue angles on the CIELAB colour wheel, the light reflectance values are based on the CIELAB Tri-Stimulus Y value with a scale of 0 – 100 (with 0 being black, and 100 being white), and the chromaticity values are CIELAB chromaticity values, again with a scale of 0 – 100 (with 0 being least, and 100 being the most). These values are described in more detail next.

The Y tristimulus value

When, as is customary, Y is evaluated such that for the similarly illuminated and viewed perfect diffuser, $Y=100$, then Y is equal to the reflectance factor, expressed as a percentage. A detailed description can be found on page 53 of "*Measuring Colour*" by R G Hunt, Third edition, ISBN 0863433871, which is hereby incorporated here in by reference.

The other colorimetric terms used in the examples relate to CIELAB colour space, otherwise known as the CIE 1976 L^* , a^* , b^* colour space. These are hue and chroma, as discussed next

Hue

Hue is an attribute of visual sensation according to which an area appears to be similar to one of or to proportions of two of the perceived colours red, green yellow and blue.

The quantitative measure of this attribute is hue angle, H . In the examples, "Hue" refers to CIE 1976 hue angle $h_{ab} = \arctan(b^*/a^*)$. This is a term understood by those skilled in the art and is described more fully on page 65, of "*Measuring Colour*" by R G Hunt, Third edition, ISBN 0863433871,

Chroma

Chroma is the colourfulness of an area judged in proportion to the brightness of a similarly illuminated area that appears to be white. The quantitative measure of this attribute is Chroma, C , where C refers to the CIE 1976 a, b , Chroma $C^*_{a,b} = (a^2 + b^2)^{1/2}$.

Again, this is a term understood by those skilled in the art and is described on page 65 of "*Measuring Colour*" by R G Hunt, Third edition, ISBN 0863433871,

5 All colorimetric terms referred to in the examples detailed below were calculated from reflectance measurements using standard values for D65 illumination and have been calculated using the CIE colour matching functions for the 1931 Standard Colorimetric Observer .

Table Example 1 Sector R (6 cards in each mood zone)						
Start of Sector R			End of sector R			
H	Y	C	H	Y	C	
349	13	8	24	17	18	
349	24	6	24	30	13	
349	41	4	24	49	8	
349	56	3	24	64	5	
349	65	2	24	73	4	
349	73	2	24	83	2	
349	25	44	24	28	43	
349	35	38	24	47	32	
349	56	24	24	63	21	
349	64	18	24	69	13	
349	71	13	24	76	9	
349	77	9	24	83	7	
349	7	23	24	7	27	
349	10	32	24	15	56	
349	11	43	24	15	50	
349	15	38	24	21	44	
349	26	34	24	30	40	
349	34	28	24	38	32	
349	13	25	24	13	44	
349	26	25	24	28	36	
349	39	18	24	42	25	
349	56	12	24	53	18	
349	68	7	24	67	11	
349	83	3	24	83	4	

10

It will be seen that the above values are arranged into blocks of six; each block of six represents the colours on one stripe card, and the position of the blocks of values in

the table corresponds to the row of the array to which the values relate. The above table represents the red blocks.

The orange block values are shown in the table below:

Table Example 1 Sector O Contains 6 cards in each mood zone					
Start of Sector O			End of sector O		
H	Y	C	H	Y	C
32	16	16	58	19	18
32	29	11	58	30	19
32	48	7	58	40	15
32	64	4	58	59	9
32	73	3	58	67	8
32	83	2	58	83	4
32	30	51	58	44	54
32	45	37	58	49	38
32	57	25	58	57	29
32	68	13	58	72	16
32	78	11	58	81	11
32	83	8	58	85	8
32	7	23	58	9	16
32	10	43	58	13	33
32	13	56	58	24	57
32	15	55	58	31	51
32	29	42	58	34	47
32	43	30	58	42	39
32	16	41	58	20	49
32	25	28	58	31	42
32	41	26	58	44	31
32	53	19	58	55	27
32	67	11	58	65	19
32	83	4	58	77	12

5

The gold values are shown in the table below:

Table Example 1 Sector Go 6 cards in each mood zone					
Start of Sector Go			End of sector Go		
H	Y	C	H	Y	C
63	18	17.7	80	20	19
63	33	16.7	80	33	14
63	51	10.9	80	51	10
63	66	7	80	67	8
63	74	5.7	80	71	7
63	83	4.4	80	79	5

63	39	59	80	56	63
63	54	44	80	61	52
63	65	33	80	70	37
63	72	25	80	79	24
63	78	15	80	81	18
63	86	11	80	85	11
63	8	19	80	12	26
63	16	41	80	23	53
63	28	65	80	49	76
63	42	73	80	61	87
63	51	68	80	66	63
63	60	58	80	71	43
63	19	49	80	41	70
63	34	47	80	49	56
63	46	35	80	58	42
63	55	27	80	64	33
63	64	17	80	69	22
63	77	12	80	77	17

The yellow values are shown in the table below:-

Table Example 1 Sector Y 5 cards in each mood zone					
Start of Sector Y			End of sector Y		
H	Y	C	H	Y	C
84	27	22.6	98	18	15
84	39	22.5	98	26	14
84	53	21.8	98	43	11
84	64	16.5	98	57	10
84	76	11.2	98	65	9
84	83	6.4	98	83	8
84	64	63	98	62	76
84	66	54	98	67	63
84	74	37	98	73	50
84	78	27	98	79	37
84	81	17	98	83	25
84	86	12	98	83	19
84	9	18	98	7	9
84	19	44	98	29	46
84	48	75	98	39	61
84	64	90	98	53	64
84	66	81	98	52	53
84	69	61	98	59	49
84	28	61	98	21	34
84	59	53	98	37	30

84	61	43	98	55	30
84	63	35	98	66	27
84	77	24	98	78	25
84	83	13	98	83	15

The green values are shown in the table below:

Table Example 1 Sector G 8 cards in each mood zone						
Start of Sector G			End of sector G			
H	Y	C	H	Y	C	
103	22	21	162	16	15	
103	35	17	162	29	12	
103	52	14	162	46	6	
103	67	13	162	63	5	
103	75	12	162	72	4	
103	83	11	162	83	3	
103	48	65	162	33	48	
103	55	56	162	44	40	
103	69	42	162	57	31	
103	78	33	162	72	22	
103	77	30	162	76	15	
103	85	17	162	83	13	
103	7	10	162	10	31	
103	29	45	162	15	35	
103	39	62	162	21	54	
103	53	57	162	33	40	
103	52	54	162	40	35	
103	59	48	162	49	30	
103	24	36	162	16	35	
103	40	30	162	28	32	
103	54	24	162	48	23	
103	71	18	162	60	16	
103	83	13	162	67	15	
103	83	10	162	83	10	

The blue values are shown in the table below:-

Table Example 1 Sector B 7 cards in each mood zone						
Start of Sector B			End of sector B			
H	Y	C	H	Y	C	
172	16	14	250	15	15	
172	24	13	250	28	12	
172	43	12	250	40	9	
172	57	9	250	55	7	
172	73	5	250	64	5	

172	83	3		250	73	3
172	31	45		250	26	39
172	50	36		250	37	35
172	64	26		250	53	26
172	71	18		250	61	21
172	77	16		250	70	12
172	82	12		250	77	8
172	8	25		250	7	15
172	16	39		250	9	25
172	18	45		250	13	36
172	33	45		250	22	32
172	40	29		250	32	26
172	57	22		250	43	21
172	19	37		250	11	26
172	33	28		250	20	24
172	49	21		250	38	29
172	61	17		250	50	16
172	75	11		250	56	13
172	83	9		250	72	9

The violet values are shown in the table below:

Table Example 1 Sector V 7 cards in each mood zone						
Start of Sector V				End of sector V		
H	Y	C		H	Y	C
262	17	13		341	9	8
262	26	11		341	20	9
262	39	10		341	35	7
262	54	8		341	48	5
262	63	7		341	64	4
262	72	3		341	73	2
262	22	35		341	27	38
262	32	31		341	47	27
262	46	23		341	60	21
262	64	14		341	69	10
262	69	10		341	75	5
262	71	9		341	83	3
262	8	188		341	6	18
262	10	337		341	9	31
262	18	351		341	9	33
262	23	340		341	15	30
262	34	304		341	27	29
262	50	177		341	45	20
262	8	26		341	11	20

262	14	24		341	23	21
262	27	24		341	36	16
262	47	16		341	54	11
262	63	10		341	67	7
262	72	3		341	83	3

- As mentioned above, the colours of the other stripe cards in any particular block fall within the ranges represented in the tables above. This is shown in the table below, which gives the CIELAB hue angle for each card, counted in each row from the left
- 5 (the count is irrespective of the block to which a card belongs). Note that in this example, as apparent from the tables above, the colours on any particular stripe card all have the same hue, and vary in luminance and chromaticity.

Example 1: Table of Hue verses Card Number from Left

Card	R	O	Go	Y	G	B	V
1	349						
2	356						
3	3						
4	10						
5	17						
6	24						
7		32					
8		37					
9		42					
10		48					
11		53					
12		58					
13			63				
14			66				
15			70				
16			73				
17			77				
18			80				
19				84			
20				87			
21				91			
22				95			
23				98			
24					103		
25					111		
26					119		
27					127		
28					135		
29					144		
30					153		
31					162		
32						172	

33						186
34						203
35						219
36						230
37						239
38						250
39						262
40						274
41						285
42						297
43						308
44						321
45						332

The data in the table above is plotted in Figure 4, from which it will be seen that there is a relatively smooth hue progression across the array along each row (the discontinuity shown arises on the transition from 360 degrees to 0 degrees, but in terms of apparent hue there is no discontinuity).

The next table below shows the relationship between card number (again counted along a row from the left) and the step on the reference colour wheel to which a card relates. It will be seen that although there are only 45 cards and 48 steps on the preferred reference colour wheel, by missing some steps out it is possible to cover the whole wheel. Moreover, in some instances the same step is also used for more than one card. Even with such design choices, however, the conformance characteristics can still be met, as will be shown later.

Example 1

Table of Colour Wheel Step versus Card Number from Left

Card	R	O	Go	Y	G	B	V
1	27						
2	28						
3	29						
4	30						
5	31						
6	33						
7		34					
8		35					
9		36					
10		38					
11		39					
12		40					
13			41				
14			42				

15			43			
16			43			
17			44			
18			45			
19				46		
20				47		
21				48		
22				1		
23				2		
24					3	
25					3	
26					4	
27					5	
28					6	
29					7	
30					8	
31					9	
32						10
33						11
34						12
35						13
36						14
37						15
38						16
39						17
40						18
41						20
42						21
43						22
44						24
45						25

With the above information, it is possible to calculate a conformance value for such an array, in the manner described previously. Recall that conformance is a measure of the degree to which the hue angles of colours in a block are within a predetermined range of the 180 degree opposite colour on the colour reference wheel, and is preferably calculated as described previously. However, as a shortcut calculation where, as in the present case, all of the colours on a particular card have the same hue angle, it is also possible to find the ratio of the number of card combinations which fall within the predetermined angle range to the number of possible card combinations. This is shown in the matrix below, for a comparison of the red and green blocks noted above (here, the red and green sectors on the reference colour wheel are almost opposite).

Red versus Green	27	28	29	30	31	33	
3	24	25	26	27	28	30	
3	24	25	26	27	28	30	
4	23	24	25	26	27	29	
5	22	23	24	25	26	28	
6	21	22	23	24	25	27	
7	20	21	22	23	24	26	
8	19	20	21	22	23	25	
9	18	19	20	21	22	24	
Red vs green	27	28	29	30	31	33	
3	1	1	1	1	1	0	
3	1	1	1	1	1	0	
4	1	1	1	1	1	0	
5	1	1	1	1	1	1	
6	1	1	1	1	1	1	
7	1	1	1	1	1	1	
8	0	1	1	1	1	1	
9	0	0	1	1	1	1	
	6	7	8	8	8	5	42
	8	8	8	8	8	8	48
							0.875

The upper matrix shows the difference in reference colour wheel steps between the hue steps on the reference colour wheel of the red block colour cards (steps 28 to 33 as shown), and the hue steps on the reference colour wheel of the green block colour cards (steps 3 to 9). Note that step 3 is repeated twice, as it is the hue of two colour cards in the green block. Given that the reference colour wheel is preferably divided into 48 steps, a 24 step difference between two steps indicates that those steps are substantially opposite on the reference colour wheel.

The lower matrix is a representation of the difference matrix obtained by applying the acceptable range value for conformity to the difference value. Here, two cards are considered to be in conformity if their hue values are within 24 ± 4 steps of each other i.e. between 20 to 28 steps of each other. Therefore, the lower matrix represents the difference matrix with a windowing function applied thereto, the windowing function being that if the difference value lies in the range then 20 to 28, then conformity is achieved and the value is replaced by a one. If outside this range the difference value is replaced by a 0.

To obtain the conformity value, the number of 1's in the lower matrix is added up, and the ratio taken of the obtained sum against the total number of entries in the matrix. In this example, the ratio is 42/48, or 0.875, to give a conformity value of 87.5%. Note that this is the conformity value just between the red and green blocks.

5

The above procedure can then be followed for every colour block pair within a row, where the sectors on the reference colour wheel of the two blocks are substantially opposite. In this example, opposing pairs of blocks, and the resulting conformity values obtained by following the above for each pair, are shown in the table below:-

10

Overall level of Conformance			
First sector	Possible Combinations	with	No. of Conforming Combinations
R	48	G	42
O	42	B	36
Go	42	V	34
Y	35	V	20
G	48	R	42
B	42	O	36
V	42	Go	34
Totals	299		244
			0.81605

Thus, as will be seen, for the array of example 1 a total of 244 conforming card combinations are obtained, out of a possible 299 combinations. This gives a conformity ratio of 81.6%. Such a conformity value is very high, and hence such an array allows for very easy colour contrasting.

15

In the above, it will be seen that the violet block has been matched against both the Gold and yellow blocks. This is because, with an odd number of blocks in a row the case will always arise where the sector of one block on the reference colour wheel is substantially opposite the adjacent sectors of two other adjacent blocks. In such a case, a choice must be made as to which of the two blocks guidance should be given that colour contrasting can be performed. This is the case in the present example, as apparent from the table above. More particularly, the violet block is the substantially opposite block to both the gold and yellow blocks. However, the conformity between the gold and violet blocks is $34/42 = 80\%$, whereas the conformity between the yellow and violet blocks is only $20/35 = 57\%$. Therefore, although the violet block is

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the block with the highest conformity with the yellow block, and hence guidance should be given on the array that when selecting a yellow as a first colour then a violet gives contrasting colours, when selecting the contrasting colour to a violet colour, the block with the highest conformity value should be chosen as the recommendation i.e.

5 in this case the gold block. Thus, guidance should be given that when selecting a violet as a first colour, then a gold would provide a contrasting colour.

Further examples will now be described. Please note that the further examples follow the format of the above described first example, and hence a less full explanation of each will be given. Reference should be made to the corresponding description of the

10 first example above if in doubt as to the meaning of the data shown.

Example 2

In this example the number of stripe cards in each row = 48 ie the same as the number of steps on the reference colour wheel. In addition, the lightness and chroma values which define the different zones are arranged differently from example 1: in particular, compared to example 1, this example shows that it is not the number of cards in each sector but the divisions of the sectors that affects the resulting conformity value.

20

Sector	Cards	Colour Wheel steps	lowest step	highest step	Lowest hue
R	7	7	27	33	346
O	7	7	34	40	29.32
Go	5	5	41	45	61.14
Y	5	5	46	2	82.28
G	7	7	3	9	97.89
B	7	7	10	16	166.59
V	10	10	17	26	256.6

The above table sets out the number of cards in each block, reference colour wheel steps, hue angle, and lowest and highest reference wheel step for the second example, in the same manner as described previously for Example 1. There follows tables setting out the hue, lightness, and chrominance values for the first and last card (from the left) in each block, for each row, in the same manner as previously presented for

25 Example 1.

Table Example 2 Sector R 7 cards in each mood zone							
Start of Sector R				End of sector R			
H	Y	C		H	Y	C	
350	7	23		27	7	27	
350	10	32		27	15	56	
350	11	43		27	15	50	
350	15	38		27	21	44	
350	26	34		27	30	40	
350	34	28		27	38	32	
350	25	44		27	28	43	
350	35	38		27	47	32	
350	56	24		27	63	21	
350	64	18		27	69	13	
350	71	13		27	76	9	
350	77	9		27	83	7	
350	13	8		27	17	18	
350	24	6		27	30	13	
350	41	4		27	49	8	
350	56	3		27	64	5	
350	65	2		27	73	4	
350	73	2		27	83	2	
350	13	25		27	13	44	
350	26	25		27	28	36	
350	39	18		27	42	25	
350	56	12		27	53	18	
350	68	7		27	67	11	
350	83	3		27	83	4	

Table Example 2 Sector O Contains 7 cards in each mood zone							
Start of Sector O				End of sector O			
H	Y	C		H	Y	C	
32	7	23		59	9	16	
32	10	43		59	13	33	
32	13	56		59	24	57	
32	15	55		59	31	51	
32	29	42		59	34	47	
32	43	30		59	42	39	
32	30	51		59	44	54	
32	45	37		59	49	38	
32	57	25		59	57	29	

32	68	13		59	72	16
32	78	11		59	81	11
32	83	8		59	85	8
32	16	16		59	19	18
32	29	11		59	30	19
32	48	7		59	40	15
32	64	4		59	59	9
32	73	3		59	67	8
32	83	2		59	83	4
32	16	41		59	20	49
32	25	28		59	31	42
32	41	26		59	44	31
32	53	19		59	55	27
32	67	11		59	65	19
32	83	4		59	77	12

Table Example 2 Sector Go 5 cards in each mood zone					
Start of Sector Go			End of sector Go		
H	Y	C	H	Y	C
63	8	19	81	12	26
63	16	41	81	23	53
63	28	65	81	49	76
63	42	73	81	61	87
63	51	68	81	66	63
63	60	58	81	71	43
63	39	59	81	56	63
63	54	44	81	61	52
63	65	33	81	70	37
63	72	25	81	79	24
63	78	15	81	81	18
63	86	11	81	85	11
63	18	17.7	81	20	19
63	33	16.7	81	33	14
63	51	10.9	81	51	10
63	66	7	81	67	8
63	74	5.7	81	71	7
63	83	4.4	81	79	5
63	19	49	81	41	70
63	34	47	81	49	56
63	46	35	81	58	42
63	55	27	81	64	33
63	64	17	81	69	22
63	77	12	81	77	17

Table Example 2 Sector Y 5 cards in each mood zone						
Start of Sector Y			Intermediate hues	End of sector Y		
H	Y	C		H	Y	C
83	9	18		95	7	9
83	19	44		95	29	46
83	48	75		95	39	61
83	64	90		95	53	64
83	66	81		95	52	53
83	69	61		95	59	49
83	64	63		95	62	76
83	66	54		95	67	63
83	74	37		95	73	50
83	78	27		95	79	37
83	81	17		95	83	25
83	86	12		95	83	19
83	27	22.6		95	18	15
83	39	22.5		95	26	14
83	53	21.8		95	43	11
83	64	16.5		95	57	10
83	76	11.2		95	65	9
83	83	6.4		95	83	8
83	28	61		95	21	34
83	59	53		95	37	30
83	61	43		95	55	30
83	63	35		95	66	27
83	77	24		95	78	25
83	83	13		95	83	15

Table Example 2 Sector G 7 cards in each mood zone						
Start of Sector G			Intermediate hues	End of sector G		
H	Y	C		H	Y	C
101	7	10		158	10	31
101	29	45		158	15	35
101	39	62		158	21	54
101	53	57		158	33	40
101	52	54		158	40	35
101	59	48		158	49	30
101	48	65		158	33	48
101	55	56		158	44	40
101	69	42		158	57	31

101	78	33		158	72	22
101	77	30		158	76	15
101	85	17		158	83	13
101	22	21		158	16	15
101	35	17		158	29	12
101	52	14		158	46	6
101	67	13		158	63	5
101	75	12		158	72	4
101	83	11		158	83	3
101	24	36		158	16	35
101	40	30		158	28	32
101	54	24		158	48	23
101	71	18		158	60	16
101	83	13		158	67	15
101	83	10		158	83	10

Table Example 2 Sector B 7 cards in each mood zone						
Start of Sector B				End of sector B		
H	Y	C		H	Y	C
176	8	25		252	7	15
176	16	39		252	9	25
176	18	45		252	13	36
176	33	45		252	22	32
176	40	29		252	32	26
176	57	22		252	43	21
176	31	45		252	26	39
176	50	36		252	37	35
176	64	26		252	53	26
176	71	18		252	61	21
176	77	16		252	70	12
176	82	12		252	77	8
176	16	14		252	15	15
176	24	13		252	28	12
176	43	12		252	40	9
176	57	9		252	55	7
176	73	5		252	64	5
176	83	3		252	73	3
176	19	37		252	11	26
176	33	28		252	20	24
176	49	21		252	38	29
176	61	17		252	50	16
176	75	11		252	56	13
176	83	9		252	72	9

Table Example 2 Sector V10 cards in each mood zone						
Start of Sector V			End of sector V			
H	Y	C		H	Y	C
261	8	188		342	6	18
261	10	337		342	9	31
261	18	351		342	9	33
261	23	340		342	15	30
261	34	304		342	27	29
261	50	177		342	45	20
261	22	35		342	27	38
261	32	31		342	47	27
261	46	23		342	60	21
261	64	14		342	69	10
261	69	10		342	75	5
261	71	9		342	83	3
261	17	13		342	9	8
261	26	11		342	20	9
261	39	10		342	35	7
261	54	8		342	48	5
261	63	7		342	64	4
261	72	3		342	73	2
261	8	26		342	11	20
261	14	24		342	23	21
261	27	24		342	36	16
261	47	16		342	54	11
261	63	10		342	67	7
261	72	3		342	83	3

Example 2							
Table of Hue verses Card Number from Left							
Card	R	O	Go	Y	G	B	V
1	350						
2	358						
3	5						
4	9						
5	14						
6	20						
7	27						
8		32					
9		36					
10		41					
11		45					
12		50					
13		54					

14		59					
15			63				
16			68				
17			72				
18			77				
19			81				
20				83			
21				86			
22				88			
23				90			
24				95			
25					101		
26					108		
27					117		
28					126		
29					135		
30					144		
31					158		
32						176	
33						194	
34						212	
35						225	
36						234	
37						243	
38						252	
39							261
40							270
41							279
42							288
43							297
44							306
45							315
46							324
47							333
48							342

The above data is plotted in Figure 5 from which it will be seen that there is a relatively smooth hue progression across the array along each row (the discontinuity shown arises on the transition from 360 degrees to 0 degrees, but in terms of apparent hue there is no discontinuity).

The next table below shows the relationship between card number (again counted along a row from the left) and the step on the reference colour wheel to which a card relates. It will be seen that because there are 48 cards, no steps on the colour wheel need be missed, and there is a one to one correspondence between cards and steps.

Example 2							
Table of Colour Wheel Step versus Card Number from Left							
Card	R	O	Go	Y	G	B	V
1	27						
2	28						
3	29						
4	30						
5	31						
6	32						
7	33						
8		34					
9		35					
10		36					
11		37					
12		38					
13		39					
14		40					
15			41				
16			42				
17			43				
18			44				
19			45				
20				46			
21				47			
22				48			
23				1			
24				2			
25					3		
26					4		
27					5		
28					6		
29					7		
30					8		
31					9		
32						10	
33						11	
34						12	
35						13	
36						14	
37						15	
38						16	
39							17
40							18
41							19
42							20
43							21
44							22
45							23
46							24
47							25
48							26

Now considering conformity, applying the same procedure as described previously in respect of Example 1, it is possible to obtain conformity values as shown in the table below:-

Overall level of Conformity			Number of Conforming Combinations
First sector	Number of possible Combinations	with	
R	49	G	43
O	49	B	43
Go	50	V	35
Y	40	V	35
G	49	R	43
B	49	O	43
V	50	Go	35
Totals	336		277
			0.824405

5

Thus, in this example, a conformity value of 82% is obtained, showing that the array has good conformity and hence will be very useful for colour contrasting.

10

As with the first example, here the violet block has been matched against the gold and yellow blocks, but instead the yellow block has the higher conformity (35/40 for yellow, versus 35/50 for gold). Thus, the yellow block should be recommended for matching against the violet block. Generally, where there is a choice of two or more blocks to match against a block, the block with the highest conformity should be chosen.

15

Example 3

A further example will now be described, the description being in the same format as above.

Sector	Cards	Colour Wheel steps	lowest step	highest step	Lowest hue
R	6	8	27	34	346
O	6	8	35	42	33.87
Go	6	4	43	46	69.78
Y	5	4	47	2	84.55
G	8	8	3	10	97.89
B	7	8	11	18	184.77
V	7	8	19	26	274.78

- The above table sets out the number of cards in each block, reference colour wheel steps, hue angle, and lowest and highest reference wheel step for the third example, in the same manner as described previously for Example 1. There follows tables setting out the hue, lightness, and chrominance values for the first and last card (from the left)
- 5 in each block, for each row, in the same manner as previously presented for Example 1.

Table Example 3 Sector R 6 cards in each mood zone						
Start of Sector R				End of sector R		
H	Y	C		H	Y	C
349	17	14		29	17	18.4
349	30	10.3		29	30	13.3
349	49	6.7		29	49	8.2
349	64	4.3		29	64	4.8
349	73	3.3		29	73	3.8
349	83	2		29	83	2
349	19	44.4		29	30	51.1
349	36	35.4		29	45	36.9
349	48	27.6		29	57	25
349	60	19.7		29	68	12.7
349	72	12.1		29	78	10.6
349	78	8.8		29	83	7.6
						0
349	7	22.9		29	7	27.1
349	10	32.1		29	15	55.5
349	11	43		29	15	50
349	15	37.5		29	21	43.6
349	26	33.5		29	30	40
349	34	27.7		29	38	31.8
						0
349	12	28.1		29	14	34.8
349	23	27		29	27	32.3
349	42	19.8		29	41	22.3
349	54	14.5		29	52	15.6
349	67	9.3		29	67	10
349	74	5.8		29	74	6.6

Table Example 3 Sector O Contains 6 cards in each mood zone					
Start of Sector O			End of sector O		
H	Y	C	H	Y	C
35	16	16.2	66	21	32.1
35	29	11.8	66	37	22.1

35	48	7.4	66	48	17.1
35	64	4.4	66	67	9.6
35	73	3.4	66	75	7.1
35	83	1.7	66	83	3.4
35	30	51.1	66	39	59.3
35	45	36.9	66	54	44
35	57	25	66	65	33.3
35	68	12.7	66	72	25.4
35	78	10.6	66	78	14.6
35	83	7.6	66	86	10.6
35	7	15.7	66	8	18.6
35	10	30.8	66	16	40.6
35	14	54.8	66	28	65
35	19	62.1	66	42	72.7
35	25	46.3	66	51	68.2
35	38	33.7	66	60	57.7
35	16	40.7	66	26	52
35	25	28.4	66	41	47.5
35	41	26.3	66	49	38.7
35	53	18.8	66	57	29.9
35	67	11.3	66	67	21.2
35	83	4	66	77	12.4

Table Example 3 Sector Go 6 cards in each mood zone

Start of Sector Go			End of sector Go		
H	Y	C	H	Y	C
70	26	32.1	84	27	22.6
70	44	21.5	84	39	22.5
70	55	16.3	84	53	21.8
70	61	13.6	84	64	16.5
70	68	11	84	76	11.2
70	75	8.4	84	83	6.4
70	36	69.4	84	56	62.7
70	55	51.8	84	61	47.5
70	60	47.5	84	73	39.8
70	71	34.7	84	81	25.6
70	78	25.5	84	83	21.4
70	85	15.6	84	86	16.6
70	9	18.6	84	12	30
70	19	46.4	84	21	50
70	34	70	84	40	60.8

70	49	79.7	84	62	81.6
70	57	68.9	84	63	74.6
70	68	47	84	73	51.9
70	27	60	84	28	61.3
70	42	46	84	59	53.3
70	53	33.7	84	61	43.1
70	65	28.5	84	63	34.6
70	74	19.2	84	77	24.2
70	78	14.6	84	83	12.9

Table Example 3 Sector Y 5 cards in each mood zone					
Start of Sector Y			End of sector Y		
H	Y	C	H	Y	C
86	23	24.6	95	18	15.2
86	36	18.5	95	26	13.7
86	53	15.1	95	43	11.3
86	67	12	95	57	9.8
86	75	11	95	65	9
86	83	6.2	95	83	7.5
86	64	78.7	95	62	75.5
86	71	56.7	95	67	62.6
86	74	38.3	95	73	49.7
86	77	42.4	95	79	36.7
86	83	25	95	83	25
86	89	13.5	95	83	18.7
86	12	26.3	95	7	9.3
86	23	52.5	95	29	46.4
86	49	75.7	95	39	61.3
86	61	86.7	95	53	63.8
86	66	62.8	95	52	53.2
86	71	42.6	95	59	48.5
86	28	61.3	95	21	33.5
86	59	53.3	95	37	29.6
86	61	43.1	95	55	29.9
86	63	34.6	95	66	26.5
86	77	24.2	95	78	24.8
86	83	12.9	95	83	15

Table Example 3 Sector G 8 cards in each mood zone						
Start of Sector G				End of sector G		
H	Y	C		H	Y	C
103	22	20		178	16	13.7
103	35	16.9		178	24	11.8
103	52	13.8		178	43	11.9
103	67	11.7		178	57	9.4
103	75	12		178	73	4.8
103	83	10.7		178	83	2.5
101	48	65		178	31	44.6
101	55	56		178	50	36
101	69	41.9		178	64	25.8
101	78	33.4		178	71	18
101	77	29.5		178	77	15.6
101	85	17.4		178	82	11.5
101	7	9.3		178	8	22.9
101	29	46.4		178	11	25.1
101	39	61.3		178	18	35.3
101	53	63.8		178	30	46.7
101	52	53.2		178	41	37.9
101	59	48.5		178	50	32
101	21	33.5		178	19	37
101	37	29.6		178	33	27.5
101	55	29.9		178	49	21.1
101	66	26.5		178	61	16.8
101	78	24.8		178	75	11.1
101	83	15		178	83	8.8

Table Example 3 Sector B 7 cards in each mood zone						
Contains colour wheel steps 11 to 18						
Start of Sector B				End of sector B		
H	Y	C		H	Y	C
191	19	15.1		269	17	12.6
191	28	13.3		269	26	10.5
191	40	11.5		269	39	10.4
191	64	8.8		269	54	7.9
191	73	6.2		269	63	6.6
191	83	3.4		269	72	3.2
191	32	34.6		269	22	34.7
191	51	29.1		269	32	30.8
191	60	23.9		269	46	23.1

191	63	21.6		269	64	13.5
191	79	10.9		269	69	9.8
191	83	6.9		269	71	9.1
						0
191	9	24.7		269	8	17.1
191	14	29.6		269	11	32.1
191	22	27.5		269	15	41
191	24	35.7		269	18	27.6
191	39	24.4		269	27	23.2
191	55	22.3		269	39	18.8
						0
191	11	22.1		269	11	21.6
191	22	19.5		269	18	21.6
191	39	16.9		269	33	16.4
191	54	15.2		269	46	12.9
191	63	12		269	63	9.4
191	72	8		269	72	4.5

Table Example 3 Sector V 7 cards in each mood zone						
Start of Sector V				End of sector V		
H	Y	C		H	Y	C
280	21	14.7		335	13	8.1
280	35	10.8		335	24	6.1
280	49	8.2		335	41	4.2
280	65	5.6		335	56	2.9
280	73	3		335	65	2.3
280	83	1.5		335	73	1.6
280	23	31		335	27	37.6
280	33	27		335	47	27.4
280	51	18.6		335	60	21.4
280	67	9.6		335	69	9.6
280	74	4		335	75	5.1
280	83	2		335	83	3
						0
280	7	26.3		335	6	17.9
280	14	43		335	9	31.3
280	16	28.7		335	9	33.3
280	24	24.5		335	15	30
280	28	22.4		335	27	28.5
280	33	20.2		335	45	19.6
						0
280	9	24.1		335	12	22.5
280	14	20.2		335	23	22.8
280	27	20.1		335	37	17.5
280	44	14.4		335	46	12.1
280	65	6.6		335	68	8.5

280	73	3.5		335	74	4.4
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Example 3

Table of Hue verses Card Number from Left

Card	R	O	Go	Y	G	B	V
1	349						
2	357						
3	8						
4	16						
5	22						
6	29						
7		35					
8		41					
9		47					
10		53					
11		60					
12		66					
13			70				
14			73				
15			76				
16			79				
17			82				
18			84				
19				86			
20				89			
21				91			
22				93			
23				95			
24					101		
25					108		
26					117		
27					126		
28					135		
29					144		
30					157		
31					175		
32						191	
33						204	
34						217	
35						230	
36						243	
37						256	
38						269	
39							280
40							290
41							300
42							307
43							315
44							325
45							335

The above data is plotted in Figure 6 from which it will be seen that there is a relatively smooth hue progression across the array along each row (the discontinuity shown arises on the transition from 360 degrees to 0 degrees, but in terms of apparent hue there is no discontinuity).

The next table below shows the relationship between card number (again counted along a row from the left) and the step on the reference colour wheel to which a card relates.

10

Table of Colour Wheel Step verses Card number from left							
Card	R	O	Go	Y	G	B	V
1	27						
2	28						
3	30						
4	31						
5	32						
6	33						
7		35					
8		36					
9		37					
10		39					
11		40					
12		42					
13			43				
14			43				
15			44				
16			45				
17			46				
18			46				
19				47			
20				48			
21				1			
22				2			
23				2			
24					3		
25					4		
26					5		
27					6		
28					7		
29					8		
30					9		
31					10		
32						11	

33						12	
34						13	
35						14	
36						15	
37						16	
38						18	
39							19
40							20
41							21
42							22
43							23
44							25
45							26

Now, considering conformity in the same manner as described above for the previous examples gives the following :-

Overall level of compliance of example 3				
First sector	Possible Combinations	with	Conforming combinations	
R	48	G	40	
O	42	B	34	
Go	42	V	35	
Y	35	V	26	
G	48	R	40	
B	42	O	35	
V	42	Go	35	
Totals	299		243	0.812709

5

Thus, even with this further arrangement different from the first and second examples already described, a conformity value of 81.2% is obtained.

Again, as with the previous examples, a choice must be made between yellow and gold as to which is recommended to contrast with violets. In this example gold is chosen, as it has the higher conformity.

10

Example 4

15 A further example will now be described.

Sector	Cards	Colour Wheel steps	lowest step	highest step	Lowest hue
R	8	8	27	34	346
O	8	8	35	42	33.87
Go	4	4	43	46	69.78
Y	4	4	47	2	84.55
G	8	8	3	10	97.89
B	8	8	11	18	184.77
V	8	8	19	26	274.78

The above table sets out the number of cards in each block, reference colour wheel steps, hue angle, and lowest and highest reference wheel step for the fourth example, in the same manner as described previously for Example 1. There follows tables
 5 setting out the hue, lightness, and chrominance values for the first and last card (from the left) in each block, for each row, in the same manner as previously presented for Example 1.

Start of Sector R				End of sector R		
H	Y	C		H	Y	C
349	17	14		29	17	18.4
349	30	10.3		29	30	13.3
349	49	6.7		29	49	8.2
349	64	4.3		29	64	4.8
349	73	3.3		29	73	3.8
349	83	2		29	83	2
349	19	44.4		29	30	51.1
349	36	35.4		29	45	36.9
349	48	27.6		29	57	25
349	60	19.7		29	68	12.7
349	72	12.1		29	78	10.6
349	78	8.8		29	83	7.6
349	7	22.9		29	7	27.1
349	10	32.1		29	15	55.5
349	11	43		29	15	50
349	15	37.5		29	21	43.6
349	26	33.5		29	30	40
349	34	27.7		29	38	31.8
349	12	28.1		29	14	34.8
349	23	27		29	27	32.3
349	42	19.8		29	41	22.3
349	54	14.5		29	52	15.6
349	67	9.3		29	67	10

349	74	5.8		29	74	6.6
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Start of Sector O				End of sector O		
H	Y	C		H	Y	C
35	16	16.2		66	21	32.1
35	29	11.8		66	37	22.1
35	48	7.4		66	48	17.1
35	64	4.4		66	67	9.6
35	73	3.4		66	75	7.1
35	83	1.7		66	83	3.4
35	30	51.1		66	39	59.3
35	45	36.9		66	54	44
35	57	25		66	65	33.3
35	68	12.7		66	72	25.4
35	78	10.6		66	78	14.6
35	83	7.6		66	86	10.6
35	7	15.7		66	8	18.6
35	10	30.8		66	16	40.6
35	14	54.8		66	28	65
35	19	62.1		66	42	72.7
35	25	46.3		66	51	68.2
35	38	33.7		66	60	57.7
35	16	40.7		66	26	52
35	25	28.4		66	41	47.5
35	41	26.3		66	49	38.7
35	53	18.8		66	57	29.9
35	67	11.3		66	67	21.2
35	83	4		66	77	12.4

Start of Sector Go				End of sector Go		
H	Y	C		H	Y	C
70	26	32.1		84	27	22.6
70	44	21.5		84	39	22.5
70	55	16.3		84	53	21.8
70	61	13.6		84	64	16.5
70	68	11		84	76	11.2
70	75	8.4		84	83	6.4
70	36	69.4		84	56	62.7
70	55	51.8		84	61	47.5
70	60	47.5		84	73	39.8

70	71	34.7		84	81	25.6
70	78	25.5		84	83	21.4
70	85	15.6		84	86	16.6
70	9	18.6		84	12	30
70	19	46.4		84	21	50
70	34	70		84	40	60.8
70	49	79.7		84	62	81.6
70	57	68.9		84	63	74.6
70	68	47		84	73	51.9
70	27	60		84	28	61.3
70	42	46		84	59	53.3
70	53	33.7		84	61	43.1
70	65	28.5		84	63	34.6
70	74	19.2		84	77	24.2
70	78	14.6		84	83	12.9

Start of Sector Y				End of sector Y		
H	Y	C		H	Y	C
86	23	24.6		95	18	15.2
86	36	18.5		95	26	13.7
86	53	15.1		95	43	11.3
86	67	12		95	57	9.8
86	75	11		95	65	9
86	83	6.2		95	83	7.5
86	64	78.7		95	62	75.5
86	71	56.7		95	67	62.6
86	74	38.3		95	73	49.7
86	77	42.4		95	79	36.7
86	83	25		95	83	25
86	89	13.5		95	83	18.7
86	12	26.3		95	7	9.3
86	23	52.5		95	29	46.4
86	49	75.7		95	39	61.3
86	61	86.7		95	53	63.8
86	66	62.8		95	52	53.2
86	71	42.6		95	59	48.5
86	28	61.3		95	21	33.5
86	59	53.3		95	37	29.6
86	61	43.1		95	55	29.9
86	63	34.6		95	66	26.5
86	77	24.2		95	78	24.8
86	83	12.9		95	83	15

Start of Sector G				End of sector G		
H	Y	C		H	Y	C
103	22	20		178	16	13.7
103	35	16.9		178	24	11.8
103	52	13.8		178	43	11.9
103	67	11.7		178	57	9.4
103	75	12		178	73	4.8
103	83	10.7		178	83	2.5
101	48	65		178	31	44.6
101	55	56		178	50	36
101	69	41.9		178	64	25.8
101	78	33.4		178	71	18
101	77	29.5		178	77	15.6
101	85	17.4		178	82	11.5
101	7	9.3		178	8	22.9
101	29	46.4		178	11	25.1
101	39	61.3		178	18	35.3
101	53	63.8		178	30	46.7
101	52	53.2		178	41	37.9
101	59	48.5		178	50	32
101	21	33.5		178	19	37
101	37	29.6		178	33	27.5
101	55	29.9		178	49	21.1
101	66	26.5		178	61	16.8
101	78	24.8		178	75	11.1
101	83	15		178	83	8.8

Start of Sector B				End of sector B		
H	Y	C		H	Y	C
191	19	15.1		269	17	12.6
191	28	13.3		269	26	10.5
191	40	11.5		269	39	10.4
191	64	8.8		269	54	7.9
191	73	6.2		269	63	6.6
191	83	3.4		269	72	3.2
191	32	34.6		269	22	34.7
191	51	29.1		269	32	30.8
191	60	23.9		269	46	23.1
191	63	21.6		269	64	13.5
191	79	10.9		269	69	9.8
191	83	6.9		269	71	9.1

191	9	24.7		269	8	17.1
191	14	29.6		269	11	32.1
191	22	27.5		269	15	41
191	24	35.7		269	18	27.6
191	39	24.4		269	27	23.2
191	55	22.3		269	39	18.8
191	11	22.1		269	11	21.6
191	22	19.5		269	18	21.6
191	39	16.9		269	33	16.4
191	54	15.2		269	46	12.9
191	63	12		269	63	9.4
191	72	8		269	72	4.5

Start of Sector V				End of sector V		
H	Y	C		H	Y	C
280	21	14.7		335	13	8.1
280	35	10.8		335	24	6.1
280	49	8.2		335	41	4.2
280	65	5.6		335	56	2.9
280	73	3		335	65	2.3
280	83	1.5		335	73	1.6
280	23	31		335	27	37.6
280	33	27		335	47	27.4
280	51	18.6		335	60	21.4
280	67	9.6		335	69	9.6
280	74	4		335	75	5.1
280	83	2		335	83	3
280	7	26.3		335	6	17.9
280	14	43		335	9	31.3
280	16	28.7		335	9	33.3
280	24	24.5		335	15	30
280	28	22.4		335	27	28.5
280	33	20.2		335	45	19.6
280	9	24.1		335	12	22.5
280	14	20.2		335	23	22.8
280	27	20.1		335	37	17.5
280	44	14.4		335	46	12.1
280	65	6.6		335	68	8.5
280	73	3.5		335	74	4.4

Example 4

Table of Hue verses Card Number from Left

Card	R	O	Go	Y	G	B	V
1	350.14						
2	358.00						
3	4.77						
4	9.32						
5	13.86						
6	20.46						
7	27.05						
8	31.59						
9		36.14					
10		40.68					
11		45.23					
12		49.77					
13		54.32					
14		58.86					
15		63.41					
16		67.50					
17			72.05				
18			76.59				
19			81.14				
20			83.41				
21				85.68			
22				87.95			
23				90.23			
24				94.77			
25					101.00		
26					108.41		
27					117.05		
28					126.14		
29					135.23		
30					144.32		
31					157.50		
32					175.68		
33						193.86	
34						211.59	
35						225.23	
36						234.32	
37						243.41	
38						252.05	
39						261.14	
40						270.23	
41							279.32
42							288.41
43							297.05
44							306.14
45							315.23
46							324.32
47							333.41
48							342.05

The above data is plotted in Figure 7 from which it will be seen that there is a relatively smooth hue progression across the array along each row (the discontinuity shown arises on the transition from 360 degrees to 0 degrees, but in terms of apparent hue there is no discontinuity).

5

The next table below shows the relationship between card number (again counted along a row from the left) and the step on the reference colour wheel to which a card relates.

Table of Colour Wheel Step verses Card number from left

Card	R	O	Go	Y	G	B	V
1	27						
2	28						
3	29						
4	30						
5	31						
6	32						
7	33						
8	34						
9		35					
10		36					
11		37					
12		38					
13		39					
14		40					
15		41					
16		42					
17			43				
18			44				
19			45				
20			46				
21				47			
22				48			
23				1			
24				2			
25					3		
26					4		
27					5		
28					6		
29					7		
30					8		
31					9		
32					10		
33						11	
34						12	
35						13	
36						14	

37						15	
38						16	
39						17	
40						18	
41							19
42							20
43							21
44							22
45							23
46							24
47							25
48							26

Considering conformity:-

Overall level of conformity of example 4				
First sector	Possible Combinations	with	Conforming combinations	
R	64	G	52	
O	64	B	52	
Go	32	V	26	
Y	32	V	26	
G	64	R	52	
B	64	O	52	
V	32	Go	26	
Totals	352		286	0.8125

Thus, again a conformity value of 81.25% is achieved, with this yet further arrangement.

Example 5

Another example will be described next. In this example, only three rows are present, and a different block pattern in terms of the number of cards in each block is used.

10 The block pattern, hue angles, hue steps and the like are shown in the table below, presented in the same manner as previously described for example 1.

Sector	Cards	Colour Wheel steps	lowest step	highest step	Lowest hue
R	6	8	27	33	346.1
O	6	5	34	38	29.32
Go	6	5	39	43	52.05
Y	5	6	44	2	74.32
G	8	8	3	10	97.98
B	7	10	11	20	184.77
V	7	6	21	26	292.73

The block hue, luminance and chromaticity ranges for each row are shown in the tables below.

Start of Sector R				End of sector R		
H	Y	C		H	Y	C
345	13	8		25	17	18
345	24	6		25	30	13
345	41	4		25	49	8
345	56	3		25	64	5
345	65	2		25	73	4
345	73	2		25	83	2
345	7	23		25	7	27
345	10	32		25	15	56
345	11	43		25	15	50
345	15	38		25	21	44
345	26	34		25	30	40
345	34	28		25	38	32
345	13	25		25	13	44
345	26	25		25	28	36
345	39	18		25	42	25
345	56	12		25	53	18
345	68	7		25	67	11
345	83	3		25	83	4

Start of Sector O				End of sector O		
H	Y	C		H	Y	C
31	15	10		52	18	18
31	28	7		52	31	14
31	40	5		52	50	9
31	55	4		52	65	5
31	64	4		52	74	5
31	73	3		52	83	3
31	7	23		52	8	19
31	10	43		52	13	37
31	13	56		52	26	60
31	15	55		52	29	56
31	29	42		52	36	47
31	43	30		52	44	38
31	14	25		52	19	43
31	27	32		52	27	40
31	41	22		52	45	26
31	52	26		52	56	19
31	67	10		52	68	12
31	74	7		52	83	5

Start of Sector Go				End of sector Go		
H	Y	C		H	Y	C
55	18	19		73	23	20
55	31	13		73	41	15
55	50	8		73	53	11
55	65	5		73	59	8
55	74	4		73	67	6
55	83	2		73	74	3
55	9	16		73	9	20
55	13	32		73	18	35
55	24	57		73	40	61
55	31	51		73	51	76
55	34	47		73	61	63
55	42	39		73	70	46
55	20	49		73	27	60
55	31	42		73	42	46
55	44	31		73	53	34
55	55	27		73	65	28
55	65	19		73	74	19
55	77	12		73	78	15

Start of Sector Y				End of sector Y		
H	Y	C		H	Y	C
77	24	17		93	18	15
77	41	17		93	26	14
77	47	15		93	43	11
77	60	10		93	57	10
77	67	8		93	65	9
77	83	4		93	83	8
77	12	30		93	7	9
77	21	50		93	29	46
77	40	61		93	39	61
77	62	82		93	53	64
77	63	75		93	52	53
77	73	52		93	59	49
77	24	47		93	21	34
77	50	59		93	37	32
77	57	36		93	55	30
77	62	35		93	66	27
77	78	23		93	78	25
77	83	10		93	83	15

Start of Sector G				End of sector G		
H	Y	C		H	Y	C
101	18	15		175	16	14
101	26	14		175	24	12
101	43	11		175	43	12
101	57	9		175	57	9
101	65	9		175	73	5
101	83	7		175	83	3
101	9	21		175	8	25
101	21	38		175	16	39
101	38	63		175	18	45
101	47	74		175	33	45
101	48	50		175	40	29
101	58	42		175	57	22
0						
101	24	35		175	19	37
101	40	30		175	33	28
101	54	24		175	49	21
101	71	18		175	61	17
101	83	13		175	75	11
101	83	10		175	83	9

Start of Sector B				End of sector B		
H	Y	C		H	Y	C
192	19	15		288	19	17
192	28	13		288	32	13
192	40	12		288	50	9
192	64	9		288	65	5
192	73	6		288	73	3
192	83	3		288	83	1
192	9	25		288	7	26
192	14	30		288	14	43
192	22	28		288	16	28
192	24	36		288	24	24
192	39	24		288	28	22
192	55	22		288	33	20
192	11	22		288	14	24
192	22	19		288	21	22
192	39	17		288	34	27
192	54	15		288	46	13
192	63	12		288	59	10
192	72	8		288	67	7

Start of Sector V				End of sector V		
H	Y	C		H	Y	C
297	10	11		333	9	9
297	17	12		333	20	9
297	36	8		333	35	7
297	49	6		333	48	5
297	65	4		333	64	4
297	73	3		333	73	2
297	8	13		333	6	18
297	8	29		333	9	31
297	11	25		333	9	33
297	19	26		333	15	30
297	22	24		333	27	29
297	31	20		333	45	20
297	10	22		333	12	22
297	21	20		333	23	23
297	35	17		333	37	18
297	53	12		333	46	12
297	68	8		333	68	9
297	74	4		333	74	4

Table of Hue verses Card Number from
Left

Card	R	O	Go	Y	G	B	V
1	345						
2	354						
3	5						
4	9						
5	17						
6	25						
7		31					
8		36					
9		40					
10		45					
11		48					
12		52					
13			55				
14			59				
15			63				
16			67				
17			70				
18			73				
19				77			
20				81			
21				85			
22				89			
23				93			
24					101		
25					108		

26					117		
27					126		
28					135		
29					144		
30					157		
31					175		
32						192	
33						219	
34						227	
35						241	
36						255	
37						273	
38						288	
39							297
40							302
41							308
42							315
43							320
44							327
45							333

The above data is plotted in Figure 8 from which it will be seen that there is a relatively smooth hue progression across the array along each row (the discontinuity shown arises on the transition from 360 degrees to 0 degrees, but in terms of apparent hue there is no discontinuity).

The next table below shows the relationship between card number (again counted along a row from the left) and the step on the reference colour wheel to which a card relates.

Table of Colour Wheel step verses card number from left							
	R	O	Go	Y	G	B	V
1	26						
2	28						
3	29						
4	30						
5	31						
6	33						
7		34					
8		35					
9		36					
10		37					
11		38					
12		38					
13			39				
14			40				
15			41				
16			42				

17			43				
18			43				
19				44			
20				45			
21				47			
22				48			
23				2			
24					3		
25					4		
26					5		
27					6		
28					7		
29					8		
30					9		
31					10		
32						11	
33						13	
34						14	
35						15	
36						16	
37						18	
38						20	
39							21
40							22
41							22
42							23
43							24
44							24
45							25

Finally, again considering conformity, calculated in the same manner as in the previous examples:-

Overall level of Conformity			
First sector	Possible Combinations	with	Conforming combinations
R	48	G	39
O	42	B	29
Go	42	B	31
Y	35	V	33
G	48	R	39
B	42	Go	31
V	35	Y	33
	292		235
			0.804795

5

Thus, with three rows a conformity value of 80.4% is achieved. Note here that in this example a different block (in this case blue) has been matched as substantially

opposing two other blocks on the reference colour wheel. Under the same principles as before, however, the block with the highest conformity (in this case the gold block) with the blue block has been selected for the guidance to be given in respect of the blue block.

5

Note that in all of the above examples the most conforming block to any particular block has been the same irrespective of the row or zone. Thus, in the above fifth example, red has been matched with green and vice versa, and this finding holds true regardless of the row in which colours are being selected (remember that the difference between rows is in tonal characteristics given by the lightness and chromaticity values). In the next and final example to be described, however, such a finding is not true, and different contrasting guidance must be given for the same colour block in a row, dependent upon the row or zone it is in.

10

15 Example 6

In this example, data for three rows are given. Here, the first row of data is the same as the same as the second row in Example 5, the second row is the same as the second row in Example 3, and the third row is the same as the fourth row in Example 1.

20

Tables showing the hue, lightness and chromaticity values for each block are given below.

Start of Sector R				End of sector R		
H	Y	C		H	Y	C
345	7	23		25	7	27
345	10	32		25	15	56
345	11	43		25	15	50
345	15	38		25	21	44
345	26	34		25	30	40
345	34	28		25	38	32
Start of Sector R				End of sector R		
H	Y	C		H	Y	C
349	19	44.4		29	30	51.1
349	36	35.4		29	45	36.9
349	48	27.6		29	57	25

349	60	19.7		29	68	12.7
349	72	12.1		29	78	10.6
349	78	8.8		29	83	7.6
Start of Sector R				End of sector R		
H	Y	C		H	Y	C
349	13	25		24	13	44
349	26	25		24	28	36
349	39	18		24	42	25
349	56	12		24	53	18
349	68	7		24	67	11
349	83	3		24	83	4

Start of Sector O				End of sector O		
H	Y	C		H	Y	C
31	7	23		52	8	19
31	10	43		52	13	37
31	13	56		52	26	60
31	15	55		52	29	56
31	29	42		52	36	47
31	43	30		52	44	38
Start of Sector O				End of sector O		
H	Y	C		H	Y	C
35	30	51.1		66	39	59.3
35	45	36.9		66	54	44
35	57	25		66	65	33.3
35	68	12.7		66	72	25.4
35	78	10.6		66	78	14.6
35	83	7.6		66	86	10.6
Start of Sector O				End of sector O		
H	Y	C		H	Y	C
32	16	41		58	20	49
32	25	28		58	31	42
32	41	26		58	44	31
32	53	19		58	55	27
32	67	11		58	65	19
32	83	4		58	77	12

Start of Sector Go				End of sector Go		
H	Y	C		H	Y	C
55	9	16		73	9	20
55	13	32		73	18	35

55	24	57		73	40	61
55	31	51		73	51	76
55	34	47		73	61	63
55	42	39		73	70	46
Start of Sector Go				End of sector Go		
H	Y	C		H	Y	C
70	36	69.4		84	56	62.7
70	55	51.8		84	61	47.5
70	60	47.5		84	73	39.8
70	71	34.7		84	81	25.6
70	78	25.5		84	83	21.4
70	85	15.6		84	86	16.6
Start of Sector Go				End of sector Go		
H	Y	C		H	Y	C
63	19	49		80	41	70
63	34	47		80	49	56
63	46	35		80	58	42
63	55	27		80	64	33
63	64	17		80	69	22
63	77	12		80	77	17

Start of Sector Y				End of sector Y		
H	Y	C		H	Y	C
77	12	30		93	7	9
77	21	50		93	29	46
77	40	61		93	39	61
77	62	82		93	53	64
77	63	75		93	52	53
77	73	52		93	59	49
Start of Sector Y				End of sector Y		
H	Y	C		H	Y	C
86	64	78.7		95	62	75.5
86	71	56.7		95	67	62.6
86	74	38.3		95	73	49.7
86	77	42.4		95	79	36.7
86	83	25		95	83	25
86	89	13.5		95	83	18.7
Start of Sector Y				End of sector Y		

H	Y	C		H	Y	C
84	28	61		98	21	34
84	59	53		98	37	30
84	61	43		98	55	30
84	63	35		98	66	27
84	77	24		98	78	25
84	83	13		98	83	15

Start of Sector G				End of sector G		
H	Y	C		H	Y	C
101	9	21		175	8	25
101	21	38		175	16	39
101	38	63		175	18	45
101	47	74		175	33	45
101	48	50		175	40	29
101	58	42		175	57	22
Start of Sector G				End of sector G		
H	Y	C		H	Y	C
101	48	65		178	31	44.6
101	55	56		178	50	36
101	69	41.9		178	64	25.8
101	78	33.4		178	71	18
101	77	29.5		178	77	15.6
101	85	17.4		178	82	11.5
Start of Sector G				End of sector G		
H	Y	C		H	Y	C
103	24	36		162	16	35
103	40	30		162	28	32
103	54	24		162	48	23
103	71	18		162	60	16
103	83	13		162	67	15
103	83	10		162	83	10

Start of Sector B				End of sector B		
H	Y	C		H	Y	C
192	9	25		288	7	26
192	14	30		288	14	43
192	22	28		288	16	28
192	24	36		288	24	24
192	39	24		288	28	22
192	55	22		288	33	20

Start of Sector B			End of sector B		
H	Y	C	H	Y	C
191	32	34.6	269	22	34.7
191	51	29.1	269	32	30.8
191	60	23.9	269	46	23.1
191	63	21.6	269	64	13.5
191	79	10.9	269	69	9.8
191	83	6.9	269	71	9.1
Start of Sector B			End of sector B		
H	Y	C	H	Y	C
172	19	37	250	11	26
172	33	28	250	20	24
172	49	21	250	38	29
172	61	17	250	50	16
172	75	11	250	56	13
172	83	9	250	72	9

Start of Sector V			End of sector V		
H	Y	C			
297	8	13	333	6	18
297	8	29	333	9	31
297	11	25	333	9	33
297	19	26	333	15	30
297	22	24	333	27	29
297	31	20	333	45	20
Start of Sector V			End of sector V		
H	Y	C			
280	23	31	335	27	37.6
280	33	27	335	47	27.4
280	51	18.6	335	60	21.4
280	67	9.6	335	69	9.6
280	74	4	335	75	5.1
280	83	2	335	83	3
Start of Sector V			End of sector V		
H	Y	C			
262	8	26	341	11	20
262	14	24	341	23	21
262	27	24	341	36	16
262	47	16	341	54	11
262	63	10	341	67	7

262	72	3		341	83	3
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Conformity values can be calculated from the data given in the previous examples from which the above data is taken, as shown in the table below:-

5

		Conformity
Example 5	Zone 1	0.805
Example 3	Zone2	0.813
Example 1	Zone3	0.816
		0.811333

Thus, a total conformity of 81.1% is obtained, but to obtain this figure it is necessary for different contrasting advice to be given for the same block in different rows, in accordance with the following table:-

10

If selecting from	R	co-ordinate with	G	in the same zone	
If selecting from	O	co-ordinate with	B	in the same zone	
If selecting from	Go	co-ordinate with	V	in the same zone	Except in zone 2 where b contrasts
If selecting from	Y	co-ordinate with	V	in the same zone	
If selecting from	G	co-ordinate with	R	in the same zone	
If selecting from	B	co-ordinate with	O	in the same zone	Except in zone 2 where Go contrasts
If selecting from	V	co-ordinate with	Go	in the same zone	Except in zone 2 where Y contrasts

Thus, from the examples it becomes apparent that colours can be selected for stripe cards in blocks which allow for high conformity figures to be obtained with many different arrangements in terms of numbers of cards, and numbers of rows, although in some cases different contrasting advice may be given for some blocks in some rows to obtain such figures.

15

Moreover, the principles of conformity as described above can be applied to produce any colour display array within the scope of the invention regardless of the particular reference colour wheel used. As will be appreciated, any particular reference wheel used which depicts acceptable contrasting colours in approximate 180 degree opposition to each other is by definition a product of prevailing fashion and artistic appreciation which specify that particular contrasting colours look good together.

20

Thus, given any reference colour wheel which opposes acceptable contrasting colours the conformity principles described above can be used in colour selection from a given reference wheel to achieve a colour display which has the necessary conformance characteristics, thus providing for easy colour contrasting by unskilled users.

To select colours for any particular block in an array can be performed by generally dividing up the steps of the reference colour wheel into the number of blocks in a row, and allocating hues to each block accordingly. However, as noted from the examples above the number of stripe cards in a block can differ dependent upon the general colour to be displayed in a block, to take into account factors such as popularity of a colour and human sensitivity to colours, as discussed previously. This leads to different blocks in a row accounting for more or less steps on the reference colour wheel than other blocks in the same row. Moreover, artistic and marketing reasons may mean that some colours are placed within blocks that detract from achieving optimal conformity. Having come up with a colour laydown, however, conformity calculations as described above can be performed to calculate the conformity of the selection, with changes then being made on an iterative basis to obtain a desired conformity value. Such changes can take into account the scientific bases for achieving an optimal conformity as described herein, as well as artistic and marketing reasons for choosing a particular colour. The lower the level of conformity value desired and the angle range over which substantially opposing hues are said to conform dictates the degree of freedom with which colours can be chosen, with a higher conformity value and smaller angle reducing the degree of freedom, for any particular reference colour wheel.

APPENDIX A

- 5 Colour standards can be measured using a DataColor Spectraflash instrument such as the Spectraflash 500 or Spectraflash 600 models. The measurement is made with Specular component included. The tristimulus (XYZ) values are calculated for illuminant D65 using 10 degree Observer data. Visual Basic functions may be used to calculate CIELab LABCH values from XYZ values, as follows:

10

Type WhitePointData

X As Single

Y As Single

Z As Single

15 End Type

'(Whitepoint data for D65,10 degree is: x 94.811, y 100, z 107.304)

Type XYZData

20 X As Single

Y As Single

Z As Single

End Type

25 Type LABData

L As Single

A As Single

B As Single

End Type

30

Type LCHData

L As Single

C As Single

H As Single

End Type

5 Function XYZ_LAB(XYZ As XYZData, wht As WhitePointData) As LABData
 'to calculate LAB values from XYZs

 Dim Xr As Single

 Dim Yr As Single

10 Dim Zr As Single

 Dim fXr As Single

 Dim fYr As Single

 Dim fZr As Single

15 Xr = XYZ.X / wht.X

 Yr = XYZ.Y / wht.Y

 Zr = XYZ.Z / wht.Z

 If Xr > 0.008856 Then

20 fXr = Xr ^ (1 / 3)

 Else

 fXr = 7.787 * Xr + 16 / 116

 End If

25 If Yr > 0.008856 Then

 fYr = Yr ^ (1 / 3)

 Else

 fYr = 7.787 * Yr + 16 / 116

 End If

30

 If Zr > 0.008856 Then

 fZr = Zr ^ (1 / 3)

 Else

 fZr = 7.787 * Zr + 16 / 116

End If

XYZ_LAB.L = 116 * fYr - 16

XYZ_LAB.A = 500 * (fXr - fYr)

5 XYZ_LAB.B = 200 * (fYr - fZr)

End Function

CLAIMS

1. A colour display system for aiding the selection and combination of colours in colour scheming, characterised in that:

the system comprises an array (10) of colour sample elements (12) each of a respective colour, the elements being grouped in discrete blocks (14) according to hue, chromaticity and lightness;

the colour sample elements of each block all have colours which are within a hue range respective to that block and which have predetermined chromaticity and lightness properties associated with that block;

the blocks are arranged in at least 3 parallel lines (16) according to their associated chromaticity and lightness properties such that all of the blocks in each line have similar or the same respective associated chromaticity and lightness properties;

each line contains M blocks, where $6 \leq M \leq 12$ which are arranged in a hue range sequence along the line;

within each block the colour sample elements are arranged in a series of hue increments in the direction of the said lines and corresponding to the sequence of their hues angles in the CIELAB colour spaces,, and in a series of lightness increments such that lightness increases in the orthogonal direction; and

the angular range of hues in each block, as defined by the CIELAB colour space, vary in size between blocks such that the blocks containing the 90 degrees CIELAB hue have a hue angle range of one half or less than one half the size of the hue angle range of the blocks containing the 270 degrees CIELAB hue.

2. A system according to claim 1, wherein the hue range sequence along each line corresponds to the sequence of the hue ranges in the visible spectrum such that the array contains M parallel non-overlapping hue range segments each running in a direction orthogonal to the lines.

3. A system according to claim 2, wherein the lines are horizontally oriented rows and the hue range segments comprise vertically oriented columns.

4. A system according to claim 3, wherein, for any first block in any one of the rows, there is another, second block which has a conformity, as hereinbefore defined,

of at least 75%, based on a reference colour wheel having n sectors of equal angle which map onto the CIELAB colour space as mapped sectors of unequal angles which, in a first angular range between 140 and 230 degrees hue in the CIELAB colour space, have an average subtended angle per sector of $(2 \pm 0.2)360/n$ degrees in the CIELAB colour space.

5. A system according to claim 4, wherein the maximum angle subtended by any of the mapped sectors in the CIELAB colour space is that of a sector lying between 150 and 220 degrees hue.

6. A system according to claim 4 or claim 5, wherein, in a second angular range of between 78 and 98 degrees in the CIELAB colour space, the mapped sectors have an average subtended angle per sector of $(0.4 \pm 0.04)360/n$ degrees.

7. A system according to any of claims 4 to 6, wherein, in a third angular range of between 1 and 79 degrees hue in the CIELAB colour space, the mapped sectors have an average subtended angle per sector of $(0.65 \pm 0.06)360/n$ degrees.

8. A system according to claim 7, wherein the mapped sectors in the third angular range exhibit a maximum subtended angle at or near 20 degrees hue on the CIELAB colour space.

9. A system according to any of claims 4 to 8, wherein n is an integer divisible by 6 and/or 8 and is at least 36.

10. A system according to any of claims 4 to 9, wherein the conformity is at least 80%.

11. A system according to any of claims 4 to 10, wherein the preferred angular deviation for calculating conformity is ± 30 degrees on the reference colour wheel.

12. A system according to any preceding claim, wherein M is 7, 8 or 9, wherein the blocks of each line include 2 blocks together encompassing a hue angle range of at

least 140 degrees in the CIELAB colour space, which range includes hues having CIELAB colour space angles of 255 degrees Hue and 315 degrees Hue.

13. A system according to claim 12, wherein the said hue ranges of the individual blocks in each line are of equal angular extent on a reference colour wheel having n sectors of equal angle which map onto the CIELAB colour space as mapped sectors of unequal angles according to at least one of the following conditions:-

- (a) in an angular range of between 140 and 230 degrees hue in the CIELAB colour space, the mapped sectors have an average subtended angle per sector of $(2 \pm 0.2)360/n$ degrees;
- (b) in an angular range of between 78 and 98 degrees in the CIELAB colour space, the mapped sectors have an average subtended angle per sector of $(0.4 \pm 0.04)360/n$ degrees; and
- (c) in an angular range of between 1 and 79 degrees in the CIELAB colour space, the mapped sectors have an average subtended angle per sector of $(0.65 \pm 0.06)360/n$ degrees.

14. A system according to any of claims 4 to 11, wherein M is an odd number and the said hue ranges of the individual blocks in each line are of unequal angular extent on the said reference colour wheel.

15. A system according to claim 14, wherein the angular extent of the hue range of one of the blocks of the line on the said reference colour wheel is at least 1.5 times the angular extent of the hue range of at least one of the other blocks of the line.

16. A system according to claim 14, wherein the angular extent of the hue range of one of the blocks of the line on the said reference colour wheel is substantially twice the angular extent of each of the hue ranges of two blocks containing hues which most closely oppose those of the said one block in the reference colour wheel, the other blocks having hue ranges of equal angular extent on the said reference colour wheel.

17. A system according to any preceding claim, wherein the lightness and chromaticity

properties of the colours of the colour sample elements in the at least 3 lines conform to the following conditions (i), (ii) and (iii) respectively:

- (i) the colour is substantially fully saturated or is a mixture of the fully saturated colour and black;
- (ii) the colour does not meet condition (i) and is a mixture of a saturated colour and a visibly significant level of white, but has no visibly significant level of black, for any given hue, the lightness being of higher than any colour in (i); and
- (ii) the colour does not meet condition (i) nor condition (ii) but is in the group of colours that are mixtures dominated by grey, but contain a visibly significant level of saturated colour, and for any hue and lightness have lower chromaticity than those colours of the same hue and lightness meeting conditions (i) and (ii).

18. A system according to claim 17, wherein the blocks are arranged in at least 4 parallel lines, having at least two lines meeting condition (iii), the colours in one of the two lines having higher chromaticity at any given hue and lightness than the colours of the other of the two lines.

19. A system according to any preceding claim, wherein the number of colour sample elements in the array is in the range of from 700 to 2400.

20. An interior or exterior design process comprising selecting and combining colours from an array (10) of colour sample elements (12) each of a respective colour, characterised in that:

the colours are grouped in the array into discrete groups (14) according to hue, chromaticity and lightness;

the colour sample elements of each group all have colours which are within a hue range respective to that group and which have predetermined chromaticity and lightness properties associated with that group

the blocks are arranged in at least 3 parallel lines (16) according to their associated chromaticity and lightness properties such that all of the groups in each zone have similar or the same respective associated chromaticity and lightness properties;

each line contains M groups, where $6 \leq M \leq 12$ which are arranged in a hue range sequence;

within each block the colour sample elements are arranged in a series of hue increments in the direction of the said lines and corresponding to the sequence of their hues angles in the CIELAB colour spaces, and in a series of lightness increments such that lightness increases in an orthogonal direction; and

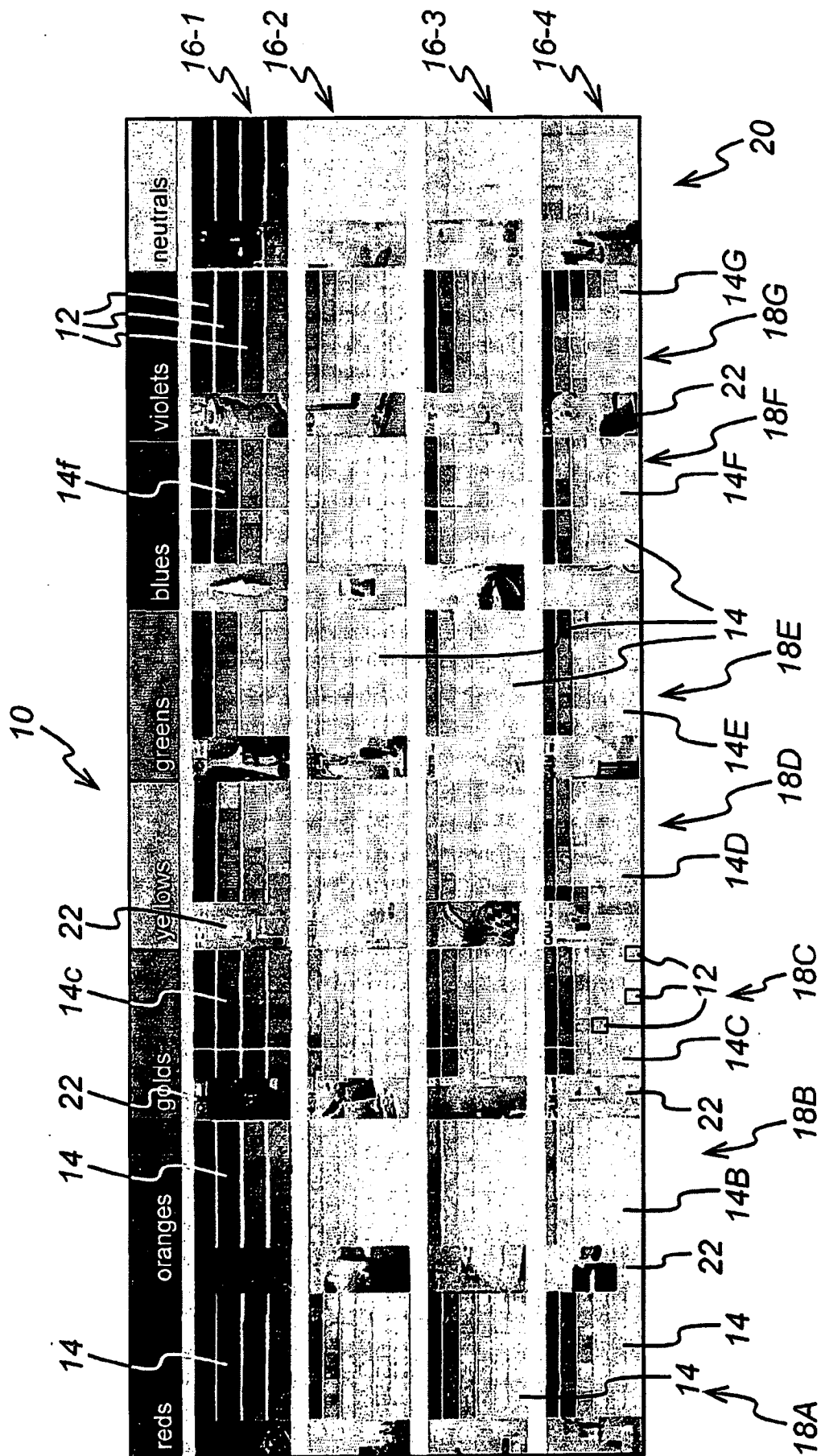
the angular range of hues in each block, as defined by the CIELAB colour space, vary in size between blocks such that the groups containing the 90 degrees CIELAB hue have a hue angle range of one half or less than one half the size of the hue angle range of the blocks containing the 270 degrees CIELAB hue.

21. A process according to claim 20, including selecting a first colour from a first said group, identifying a second said group in the same zone according to a guide pairing groups in a predetermined manner, and identifying at least one second colour from the second group to form a contrasting colour scheme.

22. A process according to claim 20 or claim 21 in which the hue ranges of the individual said groups of the array are such that for any first said group in any one of the zones, there is another, second group which has a conformity of at least 75%, based on a reference colour wheel having n sectors of equal angle which map onto the CIELAB colour space as mapped sectors of unequal angles which, in a first angular range of between 140 and 230 degrees hue in the CIELAB colour space, have an average subtended angle per sector of $(2 \pm 0.2)360/n$ degrees in the CIELAB colour space, and which in a second angular range of between 78 and 98 degrees in the CIELAB colour space, have an average subtended angle per sector of $(0.4 \pm 0.04)360/n$ degrees, wherein the term "conformity" means a parameter quantifying the degree to which elements of a one said group of colour sample elements in the array combine with elements of another group of elements in the array, the parameter being calculated (a) by counting, for each element i of the one group, the elements of the other group which have a hue within a predetermined angular deviation from the hue directly opposite that of the element i on a reference colour wheel, and (b) by summing the counts of all elements i of the one group and expressing the sum as a percentage of the total number of possible pairings of the elements i and the elements of the other group.

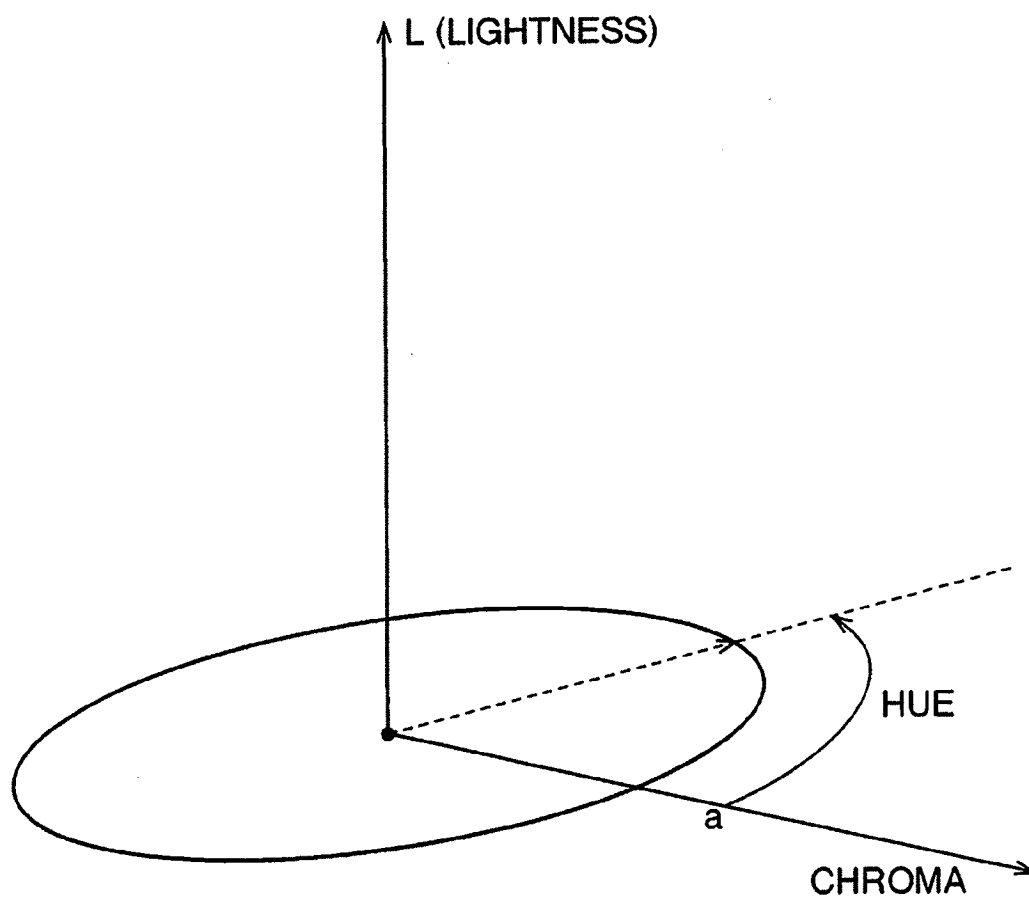
23. A method of decorating interior or exterior surfaces of a building, comprising selecting and combining colours according to the process of any of claims 20 to 22, and applying paint having the selected and combined colours to respective juxtaposed areas of the interior or exterior surfaces.
24. A method of colour scheming comprising selecting and combining colours according to the process of any one of claims 20 to 22.
25. A collection of colour items for decorating a building space, wherein the colours of the items are chosen according to the process of any of claims 20 to 22.
26. A collection according to claim 25, wherein the items comprise a collection of paints selected for a particular building space.
27. A retail space for marketing coloured items comprising a collection of such items displayed in a juxtaposed arrangement, wherein the colours of the items are chosen according to the process of any of claims 20 to 22.
28. A collection according to claim 25 or claim 26, wherein the items include any painted surfaces, fabrics, tiles, floor coverings, wallpapers, dyed surfaces.
29. A system according to any one of claims 1 to 19 further comprising at least one guide device indicating the pairing of predetermined blocks in each line.

FIG. 1



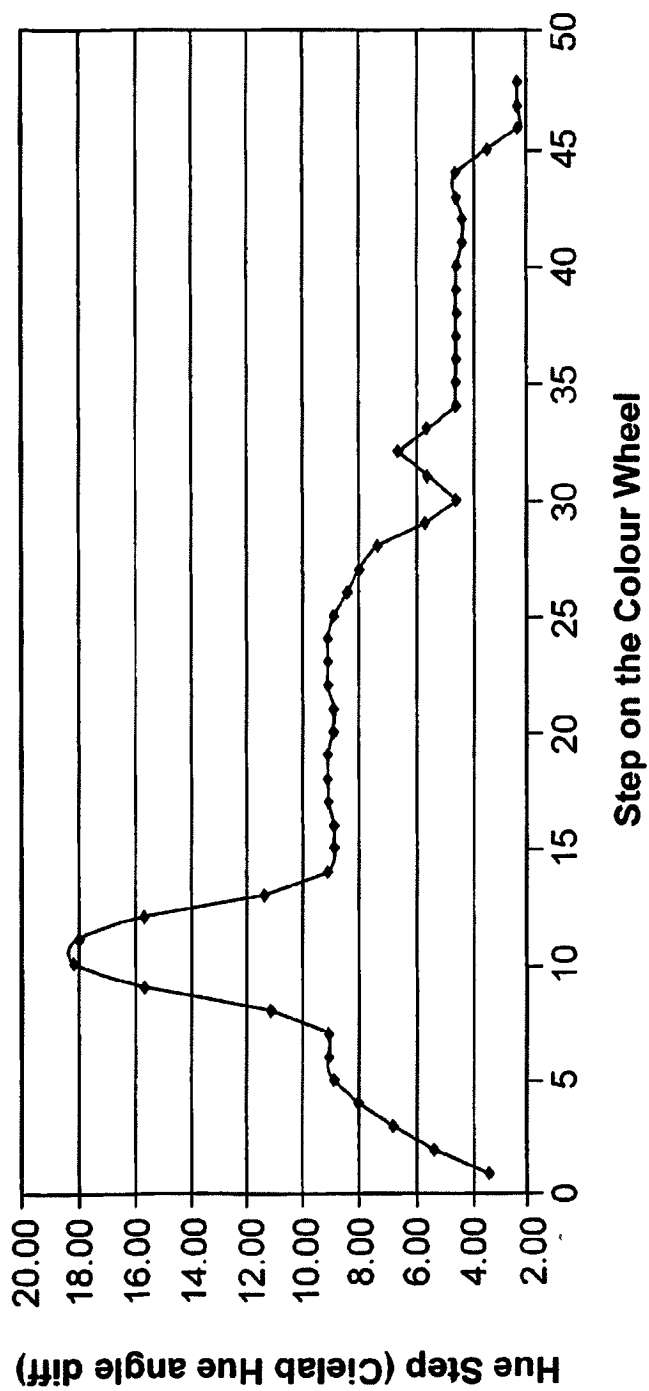
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FIG. 2

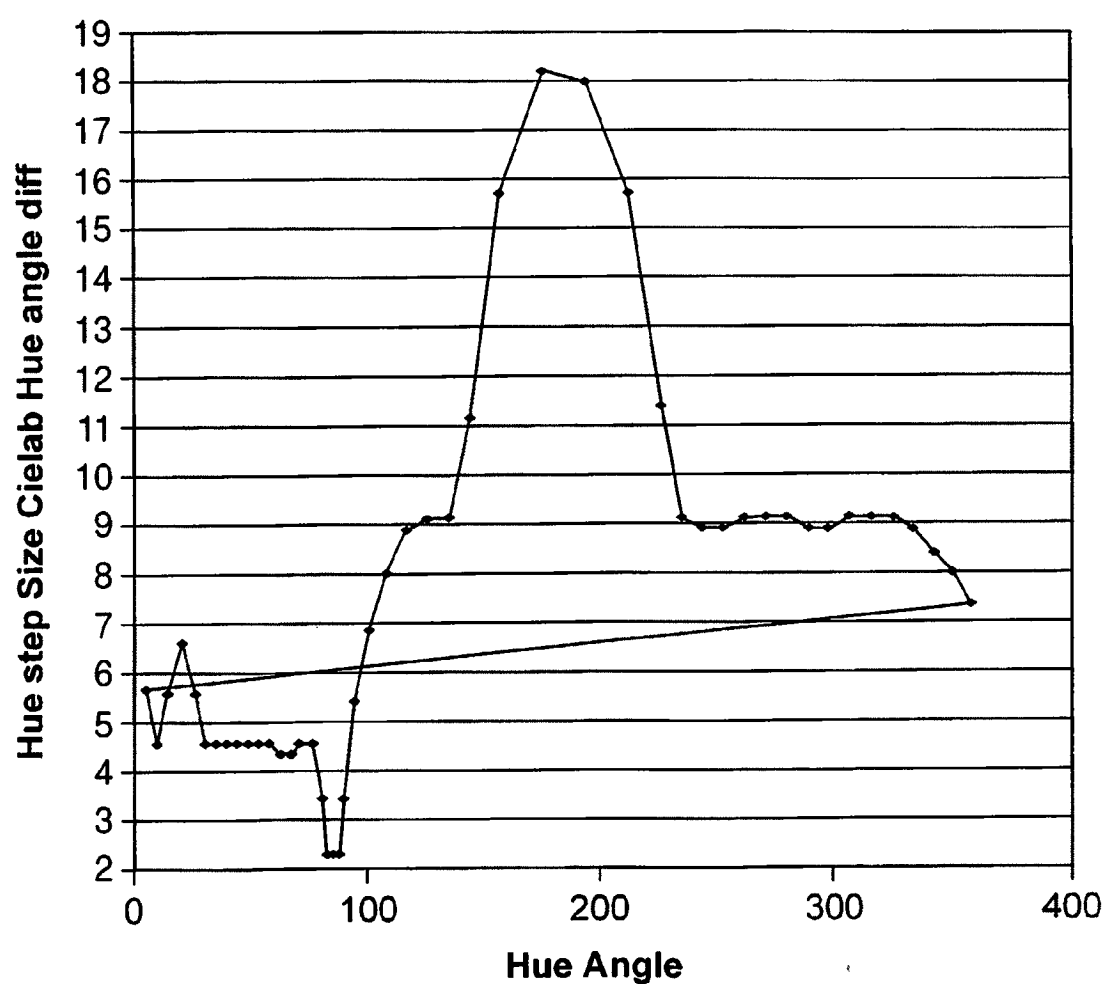


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FIG. 3A
Hue step verses Step



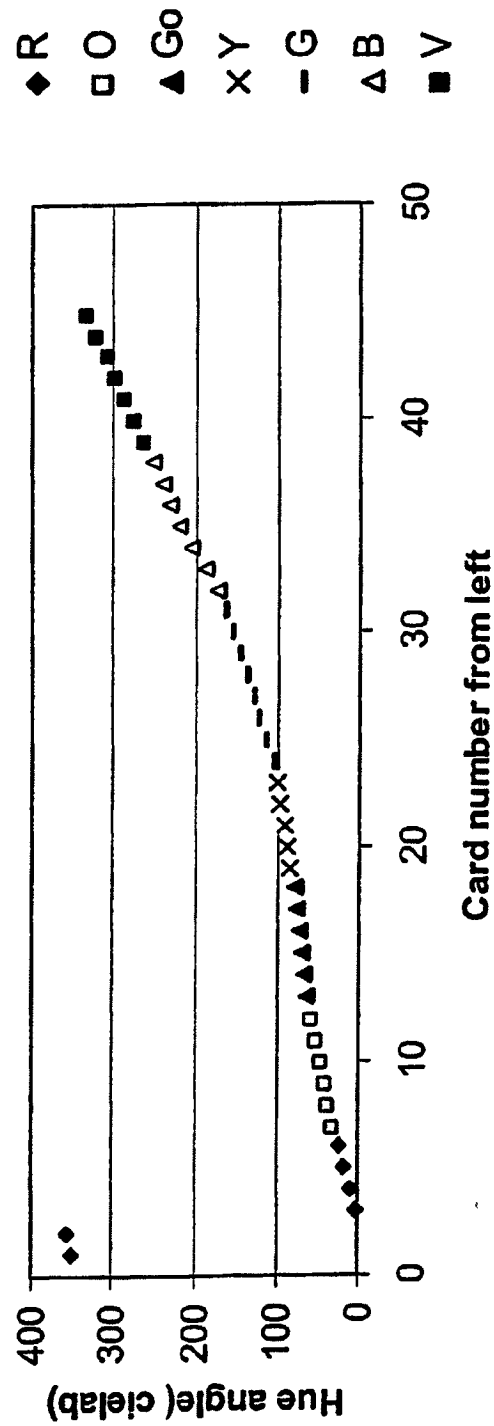
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FIG. 3B**Hue step versus Cielab Hue**

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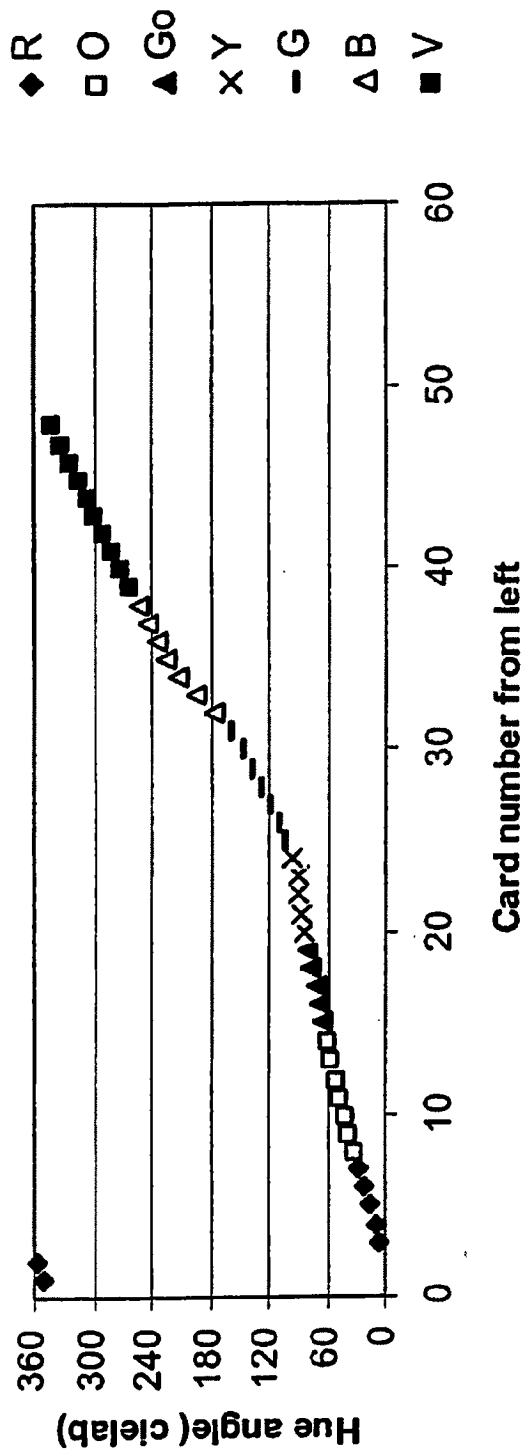
FIG. 4

Example 1: Hue verses Card

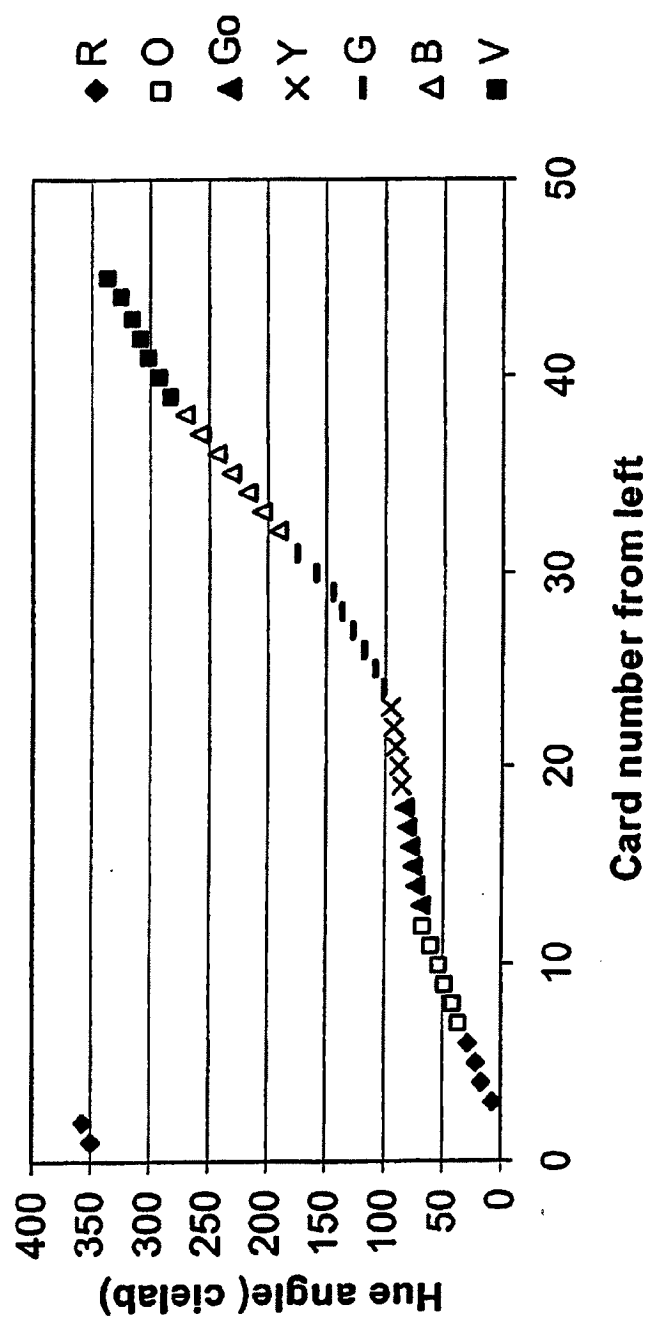


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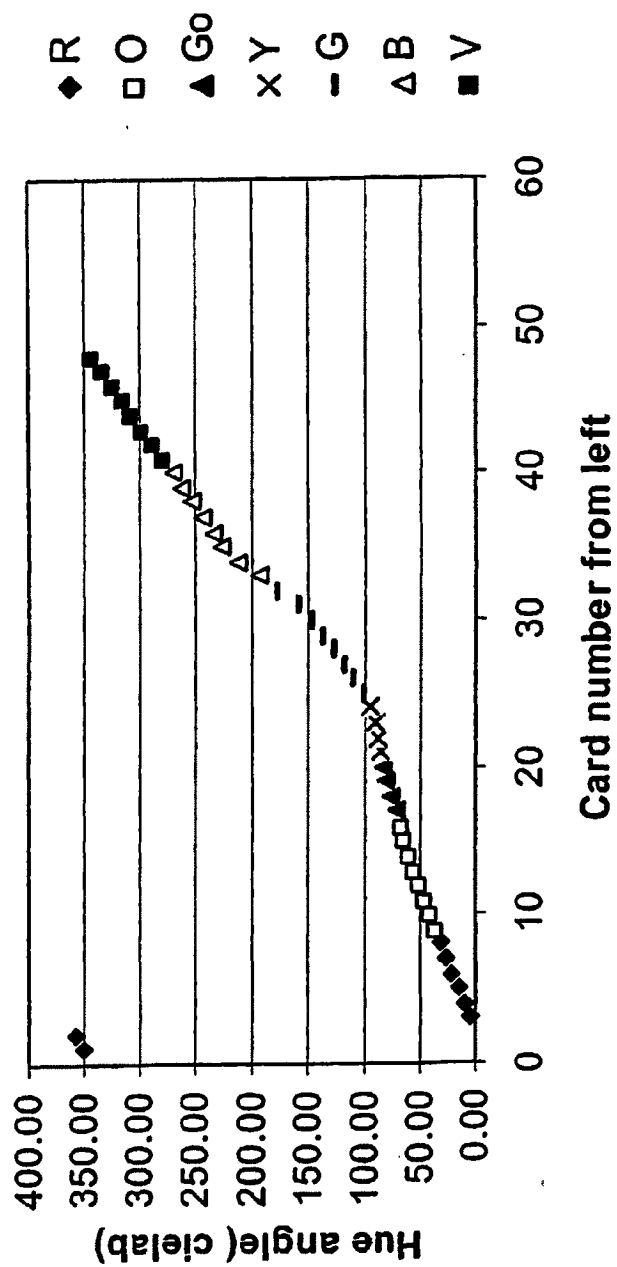
FIG. 5
Example 2: Hue verses Card



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FIG. 6**Example 3: Hue verses Card**

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FIG. 7**Example 4: Hue verses Card**

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FIG. 8

Example 5: Hue verses Card

