Informative Ornament: 'The Machine'

Enhancing the Communicative Potential of Colour

A thesis presented in partial fulfilment of the requirements for the degree of

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Abstract

Both empirical and anecdotal evidence indicates that visual communication[1] design practices implemented by designers with full colour vision often disadvantage, and sometimes endanger, colour-blind people.

The thesis *The Machine* postulates that colour-blind people – comprising approximately 8% of males and 0.5% of females (Lewis *et al.*, 1990) – are marginalized by such practices. It argues that this group could benefit from a design strategy that enhances the communicative potential and visibility of colour.

The proposed strategy involves embedding pattern into potentially confusing colours such as red and green. The embedded pattern would function for colour-blind people as an additional clue to the identity of these colours.

The thesis contends that while colour alone can be confusing for colour-blind people, patterned colour could offer a solution with a wide range of possible applications.

The research aims of *The Machine* include: developing a system of patterned colour; creating a wordless picture book that demonstrates the effectiveness of the system; constructing a narrative around the condition of red-green colour-blindness; and employing visual rhetoric[2] to increase awareness of and sensitivity to colour-blindness among those with full colour vision.

The design of the thesis is supported by research in a number of interrelated areas. These include the history of pattern post-1850, particularly in Western culture; precedents for patterned colour; and visual rhetoric in story-telling. The research also incorporates an analysis of the defining characteristics of ten late twentieth-century and early twenty-first-century wordless picture books. The thesis is further supported by applied research into patterned colour and visual rhetoric.

The Machine aims to benefit colour-blind people, a significant minority group whose visual needs are currently inadequately met. In addition, it proposes broadening the cultural role and significance of pattern. Moreover, by incorporating informative elements usually associated with pedagogic material, it aspires to extend the boundaries of the fantasy picture book genre.

[1] *Visual communication (n): communication that relies on vision (Wordnet, 2006).*

[2] *Visual rhetoric: the use of visual techniques, such as the creation of visually 'engaging' characters, as a means of persuading a target audience.*

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Introduction

Background

'If I were a hunter, I'd have killed someone by now, because they all wear red clothing and I can't see it against the bush.'

'The green LEDs on some equipment are really bad design – when they go amber to show the circuit is broken, I can't tell the difference.'

'I've been seriously lost in the bush a couple of times because I've lost sight of the red markers against the trees. Luckily I've always found the track again.'

'My workplace uses red or pink spray paint to mark where they've laid cyanide poison for possums. I can't see it at all well, especially against green grass.'

'I can't read the medical warnings on medicine bottles if they're black on a red background.'

'I can't see red on signs from a distance. I've learnt to recognise Give Way signs by their shape.'

'In Kaitoke Reserve I recently interpreted a 'no bikes' sign at the start of a trail as a 'bike trail' sign: the "X" crossing out the bike was red-on-brown... I know about the mistake only because my son corrected me at the time.'

These are a few of many similar comments I have heard colour-blind people make to describe their experience of visual communication design in New Zealand. Furthermore, as the following quotes illustrate, the problem is not restricted to this country.

'I know the positions of the three lights in U. S. traffic signals, so I don't have to worry about green/yellow/red there. But if I come to a single flashing yellow or red light, I don't know whether to slow down (yellow) or stop (red). So I ask my passenger or, lacking a passenger, do what I see the other drivers do. If there are no other cars, I stop, just in case' ('Dr. Q.', 2006, p.1).

'As a young man walking in the French Alps with my brother, who had inherited the same deficiency as myself, we failed to notice a small red arrow on the rock and so took the wrong path that led us to a crumbling ledge above a profound drop. We had already been warned that a young man had died there a few weeks earlier' (Spalding, 2004, p.345).

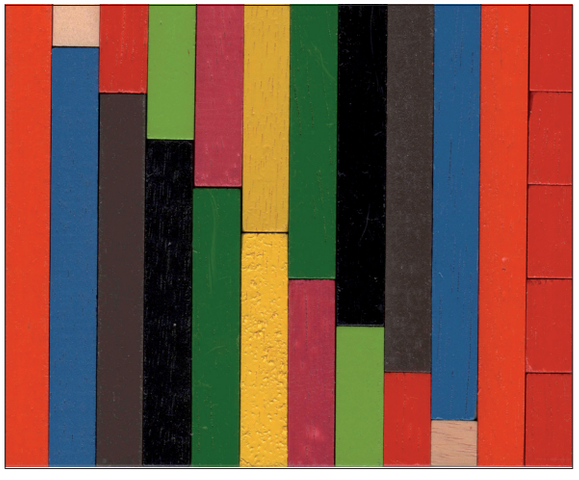
Clearly, lack of consideration of the visual needs of the colour-blind can lead to serious problems.

This thesis arises from the observation that when designers with full colour vision create visual communication design artefacts, objects and devices, colour-blind people are often disadvantaged – and sometimes endangered.

Colour-blind in a full colour world

The disadvantages of being colour-blind can begin early. In schools, particularly those for young children, colour is frequently used to convey important information. Books for emergent readers, for example, are often colour-coded by level, as in the Oxford Reading Tree series produced by Oxford University Press. Also, some teachers use colour-coded educational tools such as Cuisenaire rods. These are shaped sticks of variable length used to teach mathematical and language concepts (Figure 1).

Figure 1: *Cuisenaire rods.*



The following quote illustrates the potential drawbacks of colour-based educational practice.

> My earliest remembrance of knowing I was "color blind" was that I took a math test somewhere around 2nd or 3rd grade and failed the test. My teacher, who knew that I excelled in this subject went over the test with me so I could explain my incorrect answers. My problem? I couldn't add the blue and pink marbles correctly because I also added the purple ones ('SilentPanda', 2006, p.1).

A number of studies have highlighted the difficulties of being colour-blind in situations where colour is used to impart information. According to one such study, colour-blindness, 'whether partial or total, inhibits literacy acquisition' (Hurley, 1994, p.155). In another, P. Gallo, S. Oliva, P. B. Lantieri and F. Viviani state that analysis showed 'colour defective students were discriminated against in theoretical subject matter, relative to orthochromate students, but not in the art-related subjects. This emphasizes the need to recognize youth with colour defective vision early' (Gallo *et. al.*, 2002, p.830).

Given that colour-blindness can inhibit the acquisition of literacy, numeracy and knowledge, it seems likely that there are other, associated disadvantages. Indeed, William Wilkinson (1992, p.604) has concluded that 'color deficiency hinders the development of a normal self concept'.

Perhaps because of this underdeveloped self concept, colour-blind children often hide their condition. According to Donald

McIntyre, in general 'colour-blind children are reluctant to admit or broadcast their problem and will develop coping strategies' (McIntyre, 2002, p.112).

Unfortunately, practices such as colour-coding necessitate the development of such strategies. However, even if colour-based educational practices were no longer used in schools, colour-blind people would still be disadvantaged. As the anecdotes at the beginning of this section show, the colour-blind are subject to challenging situations in all areas of life. Researchers in an Italian study concluded that colour-blind 'Calabrian subjects admitted to experiencing colour-related difficulties with a wide range of occupational tasks and leisure pursuits' (Tagarelli *et al.*, 2004, p.436). In particular, while driving at night, 'subjects with defective colour vision had difficulty identifying reflectors on the road and the rear signal lights of cars ahead of them' (*ibid.*).

Communication for all

Such examples amply demonstrate a need for visual communication design that communicates more effectively. Moreover, they indicate a requirement for more widespread understanding of, and sensitivity to, the visual needs of colour-blind people. This thesis proposes a solution to both situations.

Colour-blindness terms

The following section, which is based on information gathered from the British Telecom web site, outlines a non-technical explanation of colour-blindness.

Humans are able to see colours because of cone-shaped cells in the eye. These cones contain pigments that are receptive to different wavelengths of light. Roughly speaking, the pigments are able to receive primarily red, or green, or blue wavelengths. The red cones are by far the most numerous, constituting 60% of the total number of cells. This percentage compares to 30% green cones and only 10% blue.

People whose eyes receive all of the three wavelengths without anomaly are said to have trichromatic ('three colour') vision.

If one of the types of receptors is not fully functional, the affected person is termed an anomalous trichromat. His or her eyes receive three colours, but reception of one wavelength is anomalous.

There are three kinds of anomalous trichromacy. They are perhaps most easily remembered as red-weak (technically the condition is called protanomaly), green-weak (deuteranomaly) and blue-weak (tritanomaly).

The other principal kind of colour-blindness is dichromacy ('two colours'). As the term suggests, only two of the types of colour receptor are present. One of the three pigments – red, green or blue – is totally missing. There are correspondingly three kinds of dichromacy, sometimes called

red-blindness (protanopia), green-blindness (deuteranopia), and blue-blindness (tritanopia). Blue-blindness is very rare, as is the inability to see any colour at all (see Table 1 for a summary of the terms).

Colour-blindness is hereditary via the X chromosome, with the result that it affects males more frequently than females. It is widely accepted that 8% of males and about 0.5% of females are colour-blind to some extent. The most common condition by far is that of green-weakness: 5% of males have this condition, while roughly 1% each are red-weak, green-blind and red-blind.

In a red-blind dichromat (protanope) there is an additional complication. As stated earlier, 60% of the cones are red-sensitive, and when these are missing, the eye is able to detect only 40% of the light received. Because of this, all colours, especially those containing red, appear considerably darker.

Table 1: *Occurrence of colour vision deficiencies in the UK*
(McIntyre 2002, p.38)

Condition		*Proportion (%)*	
		Male	*Female*
Protanopia	Red-blind	1.0	0.01
Deuteranopia	Green-blind	1.0	0.01
Tritanopia	Blue-blind	very small	very small
Protanomaly	Red-weak	1.0	0.03
Deuteranomaly	Green-weak	5.0	0.35
Tritanomaly	Blue-weak	very small	very small

Other terms used

The *Concise Oxford Dictionary* (1982) defines 'pattern' as *a repeated decorative design on wallpaper, cloth, a carpet, etc*. The term 'ornament' is defined as *decoration added to embellish esp. a building*. 'Colour' is described as *one, or any mixture, of the constituents into which light can be separated as in a spectrum or rainbow, sometimes including (loosely) black and white*.

Colour-blindness simulation palettes

Colour-blindness simulation palettes can be downloaded from a number of internet sites. Once imported into drawing software, they can be used to demonstrate how colour images appear to colour-blind people. They are introduced here because they are key to understanding the demonstrations used throughout the remainder of the thesis essay.

Figure 2 shows how a standard palette of web colours (left) is perceived by colour-blind viewers. In

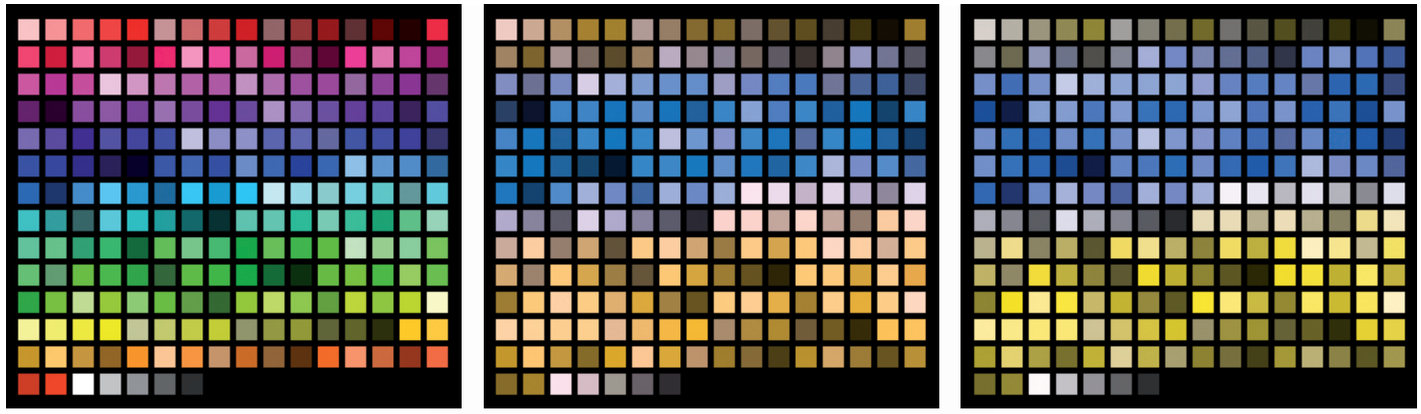


Figure 2
Colour-blindness simulation palettes. Left, standard web palette; centre, same palette as seen by green-weak viewer; right, as seen by red-weak viewer.

the centre is the standard palette as seen by a green-weak person, and on the right, as seen by a red-weak person.

Figure 3 shows a colour-blindness simulation. The image on the left is a photograph taken in native bush in New Zealand, with a red disk added to represent a track marker. The right-hand image shows the same scene after translation through a colour-blindness simulation palette, and approximates how the scene would appear to a red-weak viewer. It demonstrates how a colour-blind person could be at risk of losing his or her way while following red markers.

Figure 3:
New Zealand native bush with red track marker, and, right, the same scene after translation through a colour-blindness simulation palette.

Patterned colour

What if colour could be made more visible and informative?

In this thesis I propose embedding patterns into ambiguous colours to make them more recognizable to colour-blind people. The patterns would be standardized and of sufficient tonal contrast to make them clearly visible, thus providing a secondary clue to the colour's identity.

The patterns would be applied only to those colours that are typically confusing, for example reds and greens. As a result, confusing colour combinations such as red/green, dark red/dark blue, green/brown, or green/orange (to list a few) could be differentiated by a colour-blind viewer.

Figure 4 provides an example of patterned colour. The top left image of a boy wearing a cloak employs the colours red and green in close proximity. At the top right is the same image as it would be seen by a red-weak (protanomalous) person. It demonstrates the difficulty such a person would have in differentiating between this pair of complementary colours. In the bottom left image the original illustration is embedded with patterned colour. The corresponding colour-blindness simulation at the bottom right shows that the

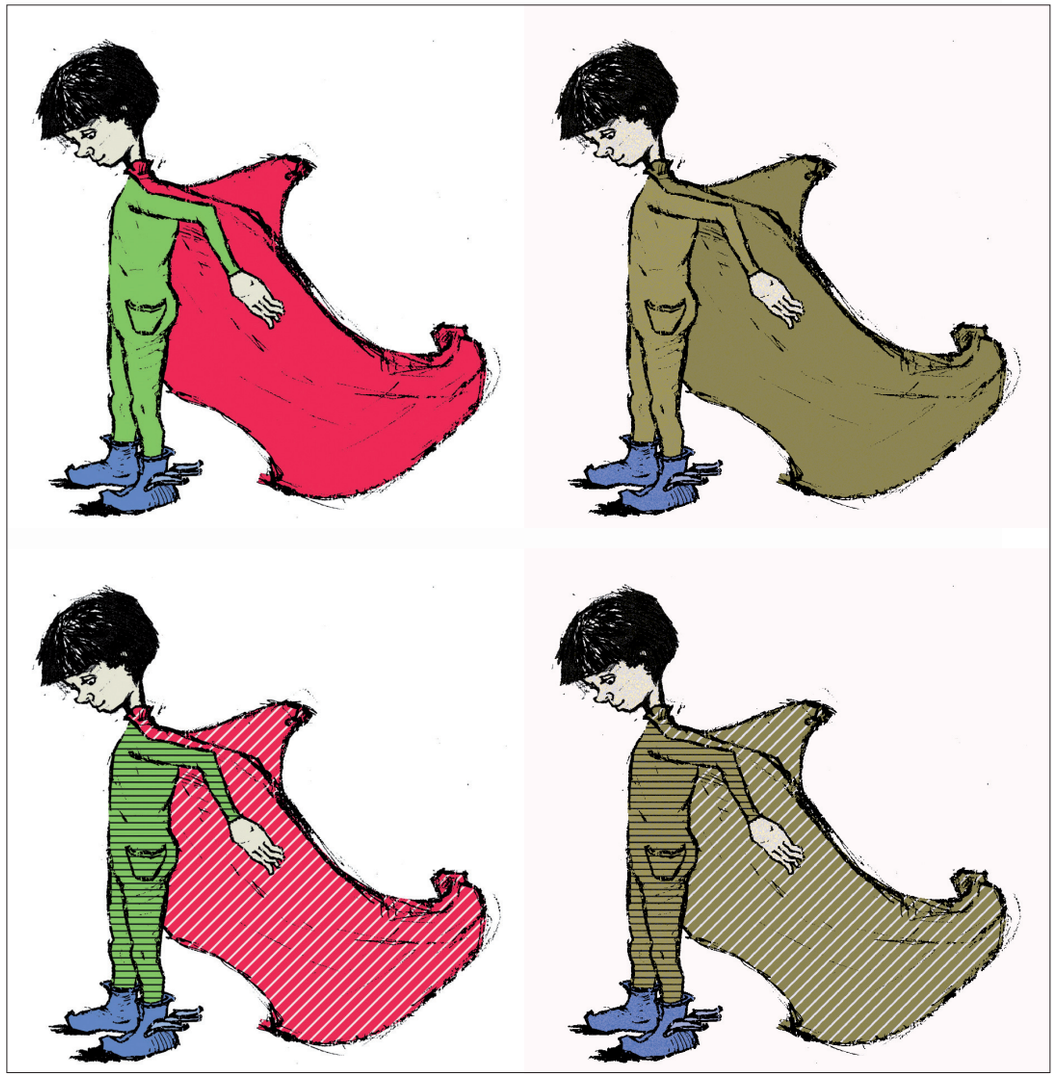


Figure 4: *Patterned colour.*

colours red and green can now be differentiated.

If there were a convention whereby a pattern of diagonal lines indicated red and a pattern of horizontal lines indicated green, a colour-blind person could conceivably identify both colours. With such a convention, patterned colour could be implemented in a number of applications to significantly improve visual understanding for the colour-blind.

Applications

A particular application for patterned colour might be in the design of illustrated books for emergent readers. Other possible applications include colour-coded educational materials such as journals, books, DVDs, CD ROMs and counting/grammar tools. The New Zealand Ministry of Education, for example, uses a colour-coding system for its Ready-to-Read books. These books are described on the Ministry's web site as a series of 'high-interest instructional reading books and related materials written in a range of genres and intended for children aged five to eight years'.

In Figure 5, the Ready-to-Read colour-coding system is reproduced at the left. On the right is a colour wheel that has been created using the same colours and then translated through a colour-blindness simulation palette. The simulation reveals that for a deuteranomalous viewer, the red, medium orange and green of the Ready-to-Read colour-coding system are virtually indistinguishable from one another, as are the yellow and light orange. A simulation as for a protanomalous viewer gives a similar result. Moreover, when the Ready-to-Read colour wheel was shown in an informal study to six colour-blind people (Appendix 2), four of the six were unable to identify the colours reliably.

I contend that patterned colour could eliminate the potential for visual confusion inherent in such a coding system.

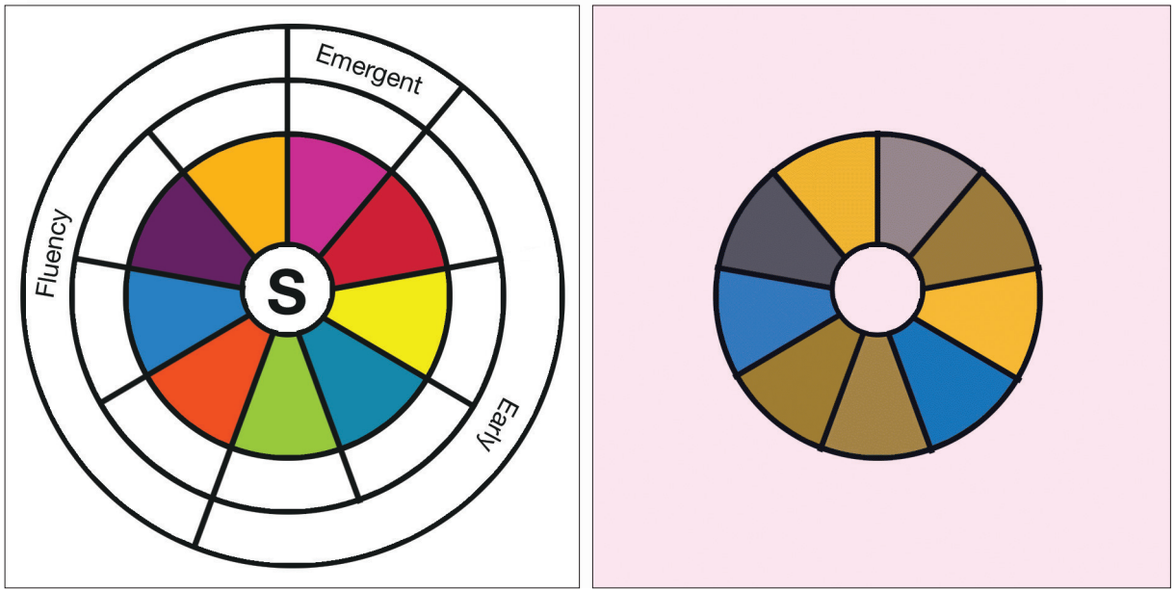


Figure 5: *(left) Ready-to-Read colour wheel,* © Ministry of Education, Wellington, New Zealand, *and (right) colour-blindness simulation using the same colours.*

As the introductory anecdotes of this thesis reveal, there are many other conceivable applications for patterned colour. These might include indicator lights on electronic devices; track markers; road signage; and traffic lights. They might even extend to safety clothing.

In some cases, such as where spray paint is used to mark the location of cyanide poison, a more suitable approach would be to improve general education about the visual needs of colour-blind people. This highlights another important intention of the thesis, namely, improving cultural awareness of and sensitivity to colour-blindness.

Patterned colour would be most profitably used where colours are of reasonably high saturation, and where there is one shade of each major colour. The visual parameters of each colour (for instance, the range of wavelengths that constitutes orange) could be defined using a colour system like the Munsell Colour System (Landa, 2005).

Alternative approaches

There have been other approaches to solving the problem of colour-blind-unfriendly colours. In parts of Canada traffic lights are shape-coded: the red light is square, the amber light diamond-shaped, and the green light is round. Morley Whillans and M. Allen (1992, p.465) report that the scheme seems to be well-accepted by users. However, I argue that the concept of shape-coding is limited to situations where the shapes of objects are individually distinct. I contend that it would not work, for instance, on colour-coded books where the whole top edge or top corner of a book cover might be designated for the identifying colour.

Some might suggest that red and green should not be used where safety is an issue, for example in traffic lights. Quite apart from the enormous expense of changing existing infrastructure, this would be inadvisable. In Western culture colours have specific, highly ingrained symbolic associations. Among the most dominant of these is the convention that red signals danger and that green means 'go'. Although such connections are lost on some colour-blind people, they are relevant to the majority of the population. It would therefore be inexpedient to try to change such deep-seated associations, or to replace red and green with other colours. Moreover, other cultures have their own symbolic meanings for colours, which would equally be disrupted by such changes.

I maintain that patterned colour, by making ambiguous colours easier for colour-blind people to recognise, would allow visual communication designers to continue to use such colours.

Summary

Colour-blind people constitute a significant minority group within society, yet currently their visual needs are not being met. Visual communication design, it appears, is not communicating to everyone.

This seems to be because general knowledge of the visual requirements of colour-blind people is poor. There is a demonstrable need not only for better communication, but for greater awareness of what it is like to be colour-blind.

The disadvantages of being colour-blind in our society begin early and can be significant. Patterned colour offers a way of using colour to convey information without the associated risk of confusing colour-blind people.

Central Proposition

Both empirical and anecdotal evidence indicates that visual communication design as practised by people with full colour vision often disadvantages, and sometimes endangers, colour-blind people.

Approximately 8% of males and 0.5% of females are colour-blind (Lewis *et al.,* 1990, in Lilliston 2000, p.1). This marginalized group could benefit from a design strategy that enhances the communicative potential and visibility of colour.

The proposed strategy involves embedding pattern into confusing colours such as red and green. The embedded pattern is designed to function as an additional clue to the identity of these colours.

I contend that while colour alone can be confusing for colour-blind people, patterned colour offers an alternative solution with a wide range of potential applications.

Research Aims

The research aims of *The Machine* include:

1 Developing a design system (patterned colour) whereby colours are more visible to a colour-blind audience.

2 Creating a wordless picture book for readers aged 5-8, demonstrating the effectiveness of this strategy.

3 Constructing a narrative around the condition of red-green colour-blindness.

4 Employing visual rhetoric and educational techniques to increase cultural awareness of and sensitivity to colour-blindness among those with full colour vision.

Methods

The research methods for the thesis *The Machine* include design research into: (a) the history of pattern from 1850 to the present, particularly in Western culture; (b) aesthetic precedents for patterned colour; (c) other precedents for patterned colour, with specific reference to key studies in the field of colour vision deficiency; and (d) the use of visual rhetoric in wordless picture books. The research also incorporates an analysis of the defining characteristics of ten late twentieth-century and early twenty-first-century wordless picture books.

The thesis is further supported by applied research into (a) the development of a system of patterned colour; and (b) techniques of visual rhetoric, in particular narrative, characterisation, design elements/layout and genre.

Discussion
Informative ornament: Designing the system

Design research

A brief history of pattern

'We have conquered ornament, we have won through to lack of ornamentation.'

'There is something about ornate, ornamental work that seems to stir the soul in most people.'

These statements are separated by ninety-six years and a gulf of opinion. The first was made in 1908 by the Czech-born architect Adolf Loos, while the second was voiced in 2004 by award-winning Canadian designer/illustrator Marian Bantjes.

However, this is not to imply that we have simply shifted in the last century from loathing ornament to adoring it. On the face of it, ornamental pattern has certainly seemed to veer from being deified by the Victorians, to being despised by the Modernists, and is currently undergoing a resurgence. According to one cultural historian, however, ornament has 'never died' (Trilling, 2001, p.186). James Trilling states that 'for most of the twentieth century [ornament] was systematically excluded from the mainstream of Western art-making and art appreciation' (Trilling, 2001, p.6). Despite this cultural exclusion, 'traditional ornament and the formalist aesthetic of craft survived the last century and a half with skill and confidence intact' (Trilling, 2005, p.1). Thus, although the urge to ornament has been much criticized, the practice seems to persist.

Occasionally people have tried to direct the decorative impulse. In 1856 the Englishman Owen Jones wrote *The Grammar of Ornament*, a book illustrating the use of ornamental pattern in China, India and other countries in which he had travelled. Jones hoped to rescue Victorian design from what he considered a lack of decorum in its decorative practice. He commented in the Foreword about an 'unfortunate tendency of our time to be content with copying, [...] the forms peculiar to any bygone age, without attempting to ascertain, [...] the peculiar circumstances which rendered an ornament beautiful, because it was appropriate' (Jones, 1856, p.1).

By the early twentieth century, Adolf Loos was declaring that the

'evolution of culture marches with the elimination of ornament from useful objects' (Loos, 1908, in Münz and Künstler, 1966, p.226).

Loos' ideas were encapsulated in his phrase 'ornament and crime'. This catch cry, coined in 1908, was widely espoused as modernism gained momentum. In 1925 Le Corbusier stated that it 'seems justified to affirm: *the more cultivated a people becomes, the more decoration disappears*' (author's italics, in Dunnett, 1987, p.viii). As modernism took hold, ornamental pattern became the target of cultural exclusion. 'Never before had so fundamental an expression of the creative spirit been singled out for elimination' (Trilling, 2001, p.6).

Figure 6: *Mucha, A., poster for Job cigarette papers, 1898.*

However, even during this ornamentally-impoverished time, decorative pattern persisted as a cultural form of expression. The wildly decorative Art Nouveau style, with its flowing plant-inspired motifs (Figure 6), was contemporaneous with Loos' work. Similarly, the streamlined geometrical motifs of the Art Deco movement, at which Le Corbusier directed much vitriol, persisted well into the mid-twentieth century.

Even Loos levelled his critical remarks only at domestic objects, claiming that '...cultural evolution is equivalent to the removal of ornament from articles in daily use' (in Münz and Künstler, 1966, p.226). Moreover, Loos' architectural style was far from being non-ornamental. Instead he initiated a stylistic practice within modernism of using the natural patterns in stone and wood to create an ornamental effect. Trilling describes this practice as the only ornamental style in the history of art that 'most of its practitioners believed to be no ornament at all' (Trilling, 2001, p.187).

The use of pattern and ornament persisted more markedly in the field of illustration and in particular the work of artists such as Kay Nielsen and Edmund Dulac. As Figures 7 and 8 show, these artists' works

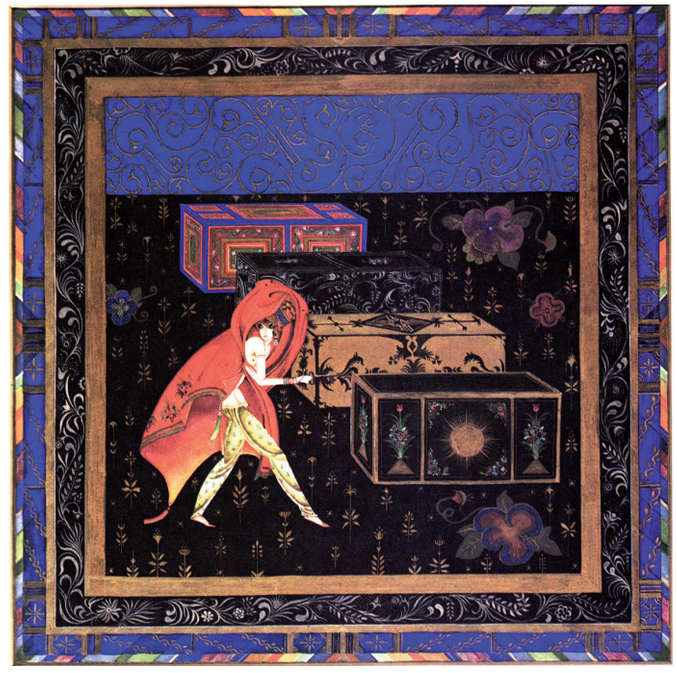


Figure 7: *Nielsen, K., from* The Steward's tale of the Sultan's wife, *1918-22.*

Figure 8: *Dulac, E.,* Caricature of Edward Dennison Ross, *1916.*

were characterized by large areas of pattern and texture. According to David Larkin, the Danish artist, Nielsen, was influenced by the 'Orientalism' that fascinated Europe during the late 19th and early 20th centuries. 'Kay all his life had an affinity for the Oriental' (Larkin, 1977, n.p.). This influence is discussed in more detail in the following section.

The American author/illustrator Maurice Sendak later used pattern and texture in many of his illustrated books as, for example *Where the Wild Things Are*. Ernest Shepard, the English illustrator of the *Winnie-The-Pooh* books, similarly used pattern and texture in many of his drawings (Figures 9 and 10). It could be argued that this was not pattern as ornament, but rather pattern as tone. Nevertheless, the overall effect is decorative and pleasing.

The modernist distaste for ornament thus seems not to have marked the field of illustration so

Figure 9: *Shepard, E. H., illustration for* Bevis, *1932*

deeply as it did the disciplines of architecture, interior design, graphic design and the fine arts. However, even in those fields and especially in the last two decades, pattern and ornament have experienced renewed favour. The visual communication design critic Alice Twemlow, writing in *Eye* magazine, states that ornament 'is clearly an integral part of the dominant visual language of the moment' (Twemlow, 2005, p.22).

Figure 10: *Shepard, E. H., illustration for* Winnie-The-Pooh, *1926.*

Present-day proponents of that visual language include, amongst others, Denise Gonzales Crisp, Jennifer Angus and Marian Bantjes. Gonzales Crisp is an illustrator and graphic designer who is interested in how decoration, ornament and pattern relate to graphic design. Angus is a textile designer whose work, according to her web site, explores the narrative potential of pattern; and Bantjes, the designer cited at the beginning of this section, creates often highly ornamented work because decoration 'makes [her] happy' (Bantjes, 2004, p.1).

These designers are discussed in more detail in the following section.

Aesthetic precedents for patterned colour

The many roles of pattern

At present it seems likely that the merits and demerits of pattern as ornament will continue to be debated by cultural practitioners and theorists. Quite apart from its aesthetic capacity, however, pattern has a number of other functions. It almost always has some role or roles beyond decoration.

The thesis *The Machine* proposes using pattern to improve the communicative qualities of colour. Therefore, pattern that has a function beyond the purely decorative is argued to be a precedent for the creation of a patterned colour system. This section discusses cases in which pattern extends beyond a simple ornamental role.

Pattern in Western culture

In Western culture pattern can denote rank, as in the stripes on a flying officer's uniform or the ermine on the robes of British nobility. Michael Snodin and Maurice Howard relate that throughout 'the centuries, the practice of the handing down of unwanted clothes from the wealthy or high-born to their servants was always attended by rituals of stripping the ornament that gave garments their upper-class distinction' (Snodin & Howard, 1996, p.98).

Moreover, pattern indicates the social and cultural conventions of a particular historical period. 'Theatre groups putting on plays of the Elizabethan and Jacobean period need only adopt a simple ruff around the neck to sum up for the audience the equivalent style of dress' (Snodin & Howard, 1996, p.107).

In sociopolitical systems, pattern sometimes indicates loyalty to a political or social movement. An example is the adoption of the tricolour as a cockade in hats during the French Revolution.

In military conflicts it is crucial to be able to differentiate one's own insignia from that of the enemy, and equally to recognise different ranks within one's own group. Such distinctions, which are accomplished through the manipulation of pattern, ensure the authentic and efficient passage of orders.

Snodin and Howard also describe a communicative use of pattern

practised in the Channel Islands of Jersey and Guernsey. Traditional sweaters worn by the fishermen of these islands 'are said to include the parish crest of the wearer so as to help identification in the case of death at sea, ensuring burial in the appropriate churchyard even if the individual cannot be named' (Snodin & Howard, 1996, p.100).

Before computers had colour screens, designers of black and white screens employed pattern to help viewers identify different types of information. Ironically, although such screens were later 'improved' by the development of colour monitors, the original ones must have been easier for colour-blind people to use.

Finally, pattern can convey semiotic significance. An example of this is the negative or restrictive connotations associated with diagonal lines, as in yellow road markings that indicate non-parking areas.

Each of the examples discussed employs pattern to convey information in a particular way. Collectively these constitute a precedent for the system of patterned colour developed for the thesis.

Figure 11: *Eisen, K.,* Courtesan in festive robes, *c. 1830.*

Eastern attitude to pattern and another precedent, ukiyo-e

Although pattern has been put to many uses in Western culture, it is safe to suggest that until the mid to late nineteenth century, the role for which it was most valued was as decoration. However, from the 1860s onwards this began to change.

At about the same time that Owen Jones was compiling *The Grammar of Ornament*, Commodore Perry of the United States Navy was negotiating the re-opening of commerce between his country and Japan. This was to end more than two centuries of commercial self-isolation that had been imposed by Japan's ruling power in 1639. This imposition effectively closed Japan's ports to all foreign trade, and resulted in a long period of economic and cultural seclusion.

Figure 12: *Kunisada, U.,* Japanese woman in check kimono, *c. 1845/6.*

Hence the art works that suddenly began to be exported with the opening up of trade and exchange were new to Western eyes. Textile art, kimono design books and *ukiyo-e* (a Japanese woodcut genre) were among the art objects that began to appear in Europe and elsewhere, thus illuminating Japanese art and culture.

Ukiyo-e, especially, revealed the Japanese regard for pattern and decoration. Siegfried Wichmann notes that textiles were depicted with sumptuous colour and clarity. 'The late *ukiyo-e* masters introduced an ever greater degree of decorative patterning into their figure pictures' (Wichmann, 1981, p.206). Moreover, he states that often 'the figure of the human being pales into insignificance in comparison with the configuration of clothing, which becomes the main point of interest' (*ibid.*) (Figure 11).

Another reason *ukiyo-e* were so novel to European audiences was their absence of the perspective traditional to Western systems of representation. According to Patricia Flynn (2007, p.1), '*Ukiyo-e* prints use clear color in a flat, opaque and two-dimensional manner.' This stylistic convention is illustrated in Figure 12, where the pattern on the wall behind the woman and child has the effect of reducing the image depth.

However, Figure 12 also shows that the convention of rendering scenes in a flat two-dimensional manner was not adhered to in all cases. Despite their fondness for two-dimensional representations of the beautiful textiles of the time, *ukiyo-e* artists also depicted three-dimensional form. The *ukiyo-e* woodcut practice of using flat colour meant that tonal variation was not available as a means of evincing form. Instead, *ukiyo-e* artists tended to rely on pattern to evoke form, as evident in the treatment of the

Figure 13: *Kunisada, U.,* The actor Onoe Kikujiro, *1855.*

kneeling man in Figure 13. While the floral pattern flattens the screen behind the actor, the pattern on the robe delineates the shape of his body.

In *ukiyo-e* therefore, pattern served not only as decoration, but as a means of flattening space or, conversely, of evoking three-dimensionality. I contend that in using pattern to alter the viewer's understanding of form and space, the woodcut artists were employing it informatively.

Figure 14: *Cassatt, M., The Letter, c. 1830.*

Furthermore, the flat colour and simple dark line utilised by *ukiyo-e* artists reinforced the visual impact of the decorative pattern that was so integral to this historical precedent.

Hence, I maintain that the aesthetic practices of these graphic artists, and their ability to similarly maximize the effectiveness of patterned colour, are crucial to the thesis and to its design products.

West meets East

Many European artists were influenced by *ukiyo-e* and its unique treatment of pattern. Some of the most well-known are the Vienna Secessionist Gustav Klimt, the Impressionists Edgar Degas and Mary Cassatt, and the Nabis Pierre Bonnard and Edouard Vuillard. As mentioned earlier, the illustrators Kay Nielsen, Edmund Dulac and Thomas Blakely Mackenzie were also influenced by *ukiyo-e*. These artists admired and emulated the aesthetic practices of *ukiyo-e* artists and extended them in new directions.

Mary Cassatt, the American artist associated with French Impressionism, saw a large exhibition of Japanese art in Paris in 1890 that included many *ukiyo-e* woodcut prints. Although she had seen such prints before, Cassatt was impressed. In a letter to Berthe Morisot she urged her friend that she '*must* see the Japanese – *come as soon as you can*' (Pollock, 1998, p.167).

Colta Ives (1974, p.45) states that after the exhibition Cassatt 'deliberately modeled a set of her own prints after specific *Ukiyo-e*' and described them as 'an imitation of Japanese methods'. Ives identifies Cassatt's 'stylistic affinities with *Ukiyo-e*: simple outlines, flat colors, and multiple patterns' (*ibid.*).

In *The Letter* (Figure 14), the wall behind the woman is flattened by the wallpaper pattern, thus reducing its perspectival depth. In contrast, the pattern on the woman's dress

Figure 15: *Bonnard, P.,* Women and dog, *1891.*

confers modelling to her form. Because Cassatt has employed flat, unmodelled colour in a manner similar to Kunisada's treatment of form, pattern is the principal clue that the woman's body is three-dimensional. Thus in this image pattern operates to flatten space and to signify form.

Other European artists took the *ukiyo-e* tradition of spatial manipulation even further than did Cassatt. Pierre Bonnard, who as Jörg Zutter points out (Zutter, (2003, p.7) was an illustrator as well as a painter, draughtsman, photographer, printmaker and interior designer, employed flat pattern as one facet of a strategy aimed at overturning single point perspective. Bonnard and his fellow Nabis sought to reproduce through their work the naïve qualities of medieval, pre-perspectival art, and accordingly emulated the tendency of medieval artists to employ 'above the subject' viewpoints. In his late nineteenth-century work, Bonnard also incorporated the all-over patterning and close-up viewpoints of the *ukiyo-e* artists.

The illustration *Women and Dog* from 1891 (Figure 15) is one such example. Zutter claims that this 'view of the group from above enables Bonnard to portray their spatial relationship in the plane although the figures themselves are completely flat and the checked dress, whose pattern does not follow the movement of the wearer, looks like a chessboard' (Zutter, (2003, p.134). By appearing to be floating above the foreground figures, the background figures remove any vestige of single-point perspective.

Form was so reduced by this treatment of space, form and decorative pattern that the result

Figure 16: *Nielsen, K.,* The Gust of Wind, *1913.*

neared abstraction. Wichmann (1981, p.208) asserts that in taking up the decorative principles evident in *ukiyo-e*, European artists 'started off on the road to abstraction'.

The illustrator Nielsen experimented with this concept in *The Gust of Wind* (Figure 16), by making pattern even flatter than in many *ukiyo-e* prints and by removing contour lines altogether. The patterns on the robe and the ground, seen as if from front-on, are dominant elements in the composition. These, combined with the lack of modelling or contour lines, have the visual effect of thoroughly flattening the picture plane.

Figure 17: *Mackenzie, T., from* Aladdin, *1929.*

Thomas Blakely Mackenzie was also influenced by *ukiyo-e*, as is evident in his book illustration for *Aladdin* from 1929 (Figure 17). Illustration work such as that exemplified by Nielsen and Mackenzie represents an illustrative precedent additional to the *ukiyo-e* aesthetic. In both instances, flat pattern is employed to manipulate the appearance of space and to alter the viewer's visual understanding of the objects within that space. Hence for the designed component of the thesis, the patterns embedded in patterned colour will not follow the form of objects but will instead be flat.

In summary, pattern was a central feature of *ukiyo-e*. It was used primarily for its decorative capacity, but had the additional role of communicating information about space and form. Western artists took up this novel use of pattern and ornament and began emulating and extending it.

Central to this thesis is the argument that visual communication design might be rendered more visually effective and inclusive through the use of pattern. This argument is based on an attitude to pattern that originated in the principles and practice of Eastern culture. The thesis *The Machine* proposes exploiting this prior knowledge to benefit a significant minority group whose visual needs are currently being inadequately met. In doing so it aims to broaden the cultural role and significance of pattern in assisting visual recognition and understanding.

Recent precedent: present-day work with pattern

Jennifer Angus is a designer who specializes in textile design at the University of Wisconsin – Madison. As her university web page reveals,

Figure 18 (above): *Angus, J.,* Locusts and Honey *installation, 2009.*

Figure 19: *Angus, J.,* Subjective Nature *installation, 2009.*

status and position within a community' (Angus, 2008A, p.1). Elsewhere she comments (2008B, p.1) that her work 'is dependent upon the supposition that there is a cultural understanding of pattern. That understanding provides a framework of a narrative. When a viewer enters one of my installations [Figure 18], he/she is greeted with something they think they know, that is, a patterned wallpaper which could be in anyone's home or office. However upon closer examination one discovers that it is entirely made up of insects. A tension is created by the beauty one observes in the pattern and the apprehension we feel toward insects.' This work, and that in Figure 19, is a contemporary example of how pattern can be used to manipulate visual understanding.

she is interested in the narrative potential of pattern and its use as a tool of communication. Angus claims that patterned 'fabric stitched into clothing can communicate sex, age, ethnic identity, region, marital

Denise Gonzales Crisp, an Associate Professor at the College of Design in North Carolina State University, is interested in 'decriminalizing the decorative' (Twemlow, 2005, p.30). She believes that the 'decorative is clearly undervalued', and argues against modernist and functionalist views that belittle decoration (*ibid.*).

Gonzales Crisp celebrates the 'rational' side of ornament, or what she regards as its 'capacity to tell, not only in a story-like way, but also in a metonymic way in the same way that icons do'. Hence she maintains that 'function is completed by ornament. ... I come from an illustration background, so the idea of being able to make pictures is more allowable to me' (*ibid.*). Gonzales Crisp also comments that the 'key or operative word to describe what's exciting about the best decorational work ... [is] 'complexity'.' She reasons that life 'is very complex and much of graphic design's time gets spent on refining and organising and making things clear. There are all kinds of ways to think about graphic design's

service, however. It can also be about establishing empathy or providing escape' (*ibid.*).

In addition to celebrating decorative pattern for its rational qualities, therefore, Gonzales Crisp views it as a means of evoking pleasure or, as Marian Bantjes might say, for stirring the soul. This view proposes ornament as escapism, or perhaps as a holiday from the rigours of modernist austerity.

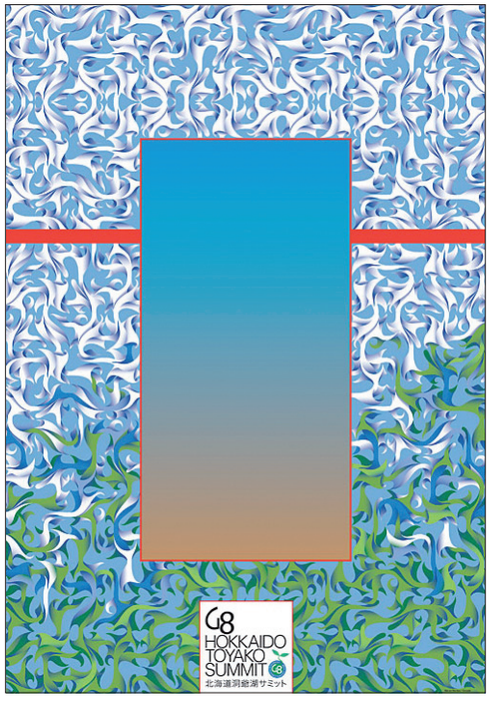


Figure 20: *Bantjes, M.,* G8 Summit poster, *2008.*

Gonzales Crisp's convictions are very much in line with the work of Marian Bantjes, the designer/illustrator quoted at the beginning of this section. Bantjes' work (Figure 20) is often exuberantly decorative. It is representative of what Trilling sees as the role of decorative pattern, namely to be 'a fundamental [...] expression of the creative spirit' (Trilling, 2001, p.6). In *Speak Up*, an on line discussion forum, Bantjes comments that decoration 'makes [her] happy' (Bantjes, 2004, p.1).

Summary of aesthetic precedents for patterned colour

There are many precedents for pattern that conveys information. Ornamental pattern can convey cultural particulars such as social rank or political allegiance. Similarly, pattern can enable classification, as with geological maps that use pattern to indicate areas of different geological type. Pattern can have semiotic meaning, for instance in the diagonal lines that connote danger or prohibition. Moreover, it can function to manipulate the viewer's understanding of visual space, by either flattening that space or evoking three-dimensionality.

One of the principal aims of the thesis is to create an object that is visually appealing and therefore elicits empathy in its target audience. Ornamental pattern will form part of that strategy. Hence the views espoused by Gonzales Crisp and Bantjes, and the current work of Angus, form additional precedents for the design of *The Machine*.

Patterned colour in the picture book *The Machine* will adopt a number of these precedents. It will impart cultural information (albeit specific to Western culture) through its semiotic content. The pattern for red will have diagonal elements suggesting prohibition and danger, while that for green will have associations with entanglement. Patterned colour will enable classification by allowing colour-blind viewers to distinguish between

visually-confusing colours. The embedded pattern will be flat, which in turn will flatten the picture plane in that area and thereby manipulate the visual understanding of the viewer. It will communicate with colour-blind people as well as with the non colour-blind. Finally, it will reinforce the narrative by reflecting key events in the picture book.

Other precedents for patterned colour

Ishihara's Colour-blindness Plates

The Ishihara Colour-blindness Plates, a widely-used colour-blindness test that employs pattern, originated in Japan. The inventor of these plates was Shinobu Ishihara, an army doctor who in 1915 was assigned the task of designing a colour-blindness test for soldiers. The first version of the test was completed in 1916, and later variants are still in use today.

Ishihara's cultural heritage, with its high regard for pattern and decoration, might well have predisposed him to use pattern in his work. The Ishihara test uses coloured patterns to identify different types of colour vision. The plates comprise circles of irregularly arranged coloured dots. Depending on the type of colour vision of the viewer, the plates appear to contain embedded numbers, or lines, or no discernible shapes.

Often, and as shown in Figure 21, two images appear in the same plate. Viewers with full colour vision see a figure 8, while many colour-blind people see the figure 3.

The visual and scientific elegance of Ishihara's design is matched by that of his concept. The test is inclusive in that it measures difference, rather than failure, of perception. In many of the plates, almost everyone sees something. In some plates colour-blind viewers can see shapes where those with full colour vision can see none.

Like the artistic and aesthetic precedents discussed previously, Ishihara's work demonstrates the informative capacities of pattern. More importantly for this thesis, it indicates that both colour and pattern can be used to communicate with audiences either selectively or broadly.

Key studies in the field of colour vision deficiency

The literature concerning colour vision deficiency is informative

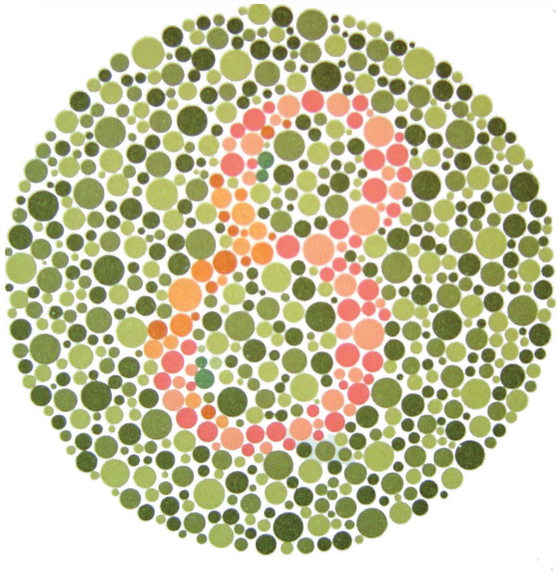


Figure 21: *Ishihara, S., in* The series of plates designed as a test for colour-blindness, *Plate 2.*

regarding visual communication design practices that affect colour-blind people. Knowledge of such practices is important for the thesis, as it illuminates which to embrace and which to avoid in designing a system of patterned colour.

A search of the literature revealed no research specifically about colour-blindness in New Zealand. This is surprising, given that the condition affects so many people. One researcher speculates that a general disinterest in the condition exists because 'color deficiency is deemed a minor weakness' (Wilkinson, 1992, p.603). However, judging by the number of new studies completed in the past five to ten years, awareness is increasing about the day-to-day difficulties experienced by colour-blind people.

In *Accessible advertising for visually-disabled persons: the case of color-deficient consumers*, Carol Kaufman-Scarborough used a semi-structured survey to question colour-blind consumers about the efficacy of visual communication materials. Specifically, she asked whether the subjects had ever had problems with the colours used in advertising, and if so, which colours. She also asked the survey participants for recommendations about improved design practices.

The author found that some of the subjects were frustrated by a lack of sensitivity towards their visual needs. One respondent commented that 'I sometimes feel like an adult illiterate finding ways to cope...' (Kaufman-Scarborough, 2001, p.313), Nevertheless they were able to be very specific about what design practices did not work for them.

These practices included the use of some colour combinations, such as red and green, black and red, and green and yellow, especially if the colours were of similar tone. The use of coloured backgrounds behind text also caused difficulty, particularly where there was little or moderate contrast between them. Other sources of frustration were colour coding and the use of 'bright' colours such as red for emphasis. (For most colour-blind people, red is a relatively dark colour.)

Kaufman-Scarborough claims that 'advertisers often neglect to test for accessibility by visually-disabled persons' (*ibid*, p.303). She concludes that designers often over-use colour for its emotional associations and at the expense of clarity. Hence she suggests that while there is a place for colour in advertising, designers need to ensure that 'the largest number of potential recipients gets the message' (*ibid*, p.317).

In a review article about colour vision deficiency in the medical profession, Tony Spalding analysed the literature on 'the prevalence of [colour vision deficiency] in the medical profession and its effects on medical skills' (Spalding, 1999, p.469). Although much of the information is not relevant to this thesis, Spalding notes that in a study of forty general practitioners with colour vision deficiency, twenty-two

had difficulty using colorimetric tests for analysing urine and blood. According to the web site of GlucoseMeters4u.com (n.d.), colorimetric tests are plastic strips with a test area that changes colour according to the amount of glucose in the urine or blood.

In his review Spalding points out that there have been many studies showing that diabetics with colour vision difficulties (either congenital or disease-induced) 'make errors in reading certain colorimetric tests' (Spalding, 1999, p.473). The accuracy of such tests is vital to diabetics. I argue that a system of patterned colour introduced into the tests could remove their inherent potential for visual confusion and thereby make them more reliable.

In the 1990s a study was conducted into the colour visibility of the Dallas, Texas fire engine livery. Stephen Solomon and James King analysed accident data recorded by the Dallas Fire Department during the 1970s and 1980s. The findings indicated that lime yellow is a much safer colour than the traditional red. Solomon and King's study was reported in an on line resource from the American Psychological Association in 2003 (p.1):

> In the 1970s and early 1980s, the City of Dallas started replacing its all-red fire vehicles with lime-yellow fire vehicles with white upper cabs. After the early 1980s, the fire department bought red vehicles with white cabs. During their four-year study published in 1995, Solomon and King found that the risk of a visibility-related, multiple-vehicle accident may be as much as three times greater for red or red/white pumpers compared to lime-yellow/white pumpers. The results also show that when lime-yellow/white fire emergency vehicles are involved in an accident, the likelihood of injury or towaway damage is less than for red or red/white vehicles involved in an accident.

In a study titled *'Colour-blind drivers' perception of traffic signals'*, Morley Whillans (1983, p.1187) states that colour-blind drivers 'have difficulties recognizing traffic and vehicle signals. However, simple and practical solutions such as changes to the design, colour and shape of signals will aid these drivers.'

Whillans surveyed two groups of colour-blind drivers, using a questionnaire, informal interviews and correspondence. He also used simulated traffic signals – some shape-coded and some standard – to test and compare the responses of colour-blind and non-colour-blind subjects.

Whillans found that in his signal recognition tests all of the colour-blind subjects preferred shape-coded signals, and additionally, none of the non-colour-blind subjects found them inferior to standard signals. Significantly, all of the subjects found the signals 'more distinctive when framed by white light or when crossed by a white bar' (p.1188).

While shape coding is not appropriate in all situations (see *Background*), Whillans' research supports the use of pattern as a means of differentiating between confusing colours.

In a study reported in *Human Factors*, Kylie O'Brien, Barry Cole, Jennifer Maddocks and Andrew Forbes studied the conspicuity of differently-coloured road signs. They found that for deuteranopes (green-blind individuals), the conspicuity of red, orange and green colour-coded traffic control devices was significantly less than for those with full colour vision.

However, this was not the case when yellow and blue colour-coded signs were used. The research findings indicated that yellow and blue were equally conspicuous to colour-blind and non-colour-blind subjects. The researchers concluded that 'redundant color coding does contribute to the conspicuity of signs and signals and that deuteranopes – and probably those with other severe forms of defective color vision – have a significantly reduced ability to notice colored targets, such as road signs and signals, in complex visual environments' (O'Brien *et al.*, 2002, p.665).

How to make figures and presentations that are friendly to color blind people, by Masataka Okabe and Kei Ito (2002), provides theoretical background about colour-blindness. It also details particular design practices that cause difficulty for colour-blind people, and describes how to avoid such practices. While the article focuses mostly on graphs and micrographs, the discussion of colour principles is relevant to the design field.

Okabe and Ito's findings point to a number of key facts, namely: that many colour-blind people cannot distinguish between certain colours, particularly blues vs. violets and reds vs. greens; that dark red or violet symbols, and thin lines or fine text, will not show up well on black or dark blue backgrounds; and that dark red looks like black to some colour-blind people, so should not be used for emphasis.

The authors provide examples of poorly designed graphs and charts where colour is the only means of distinguishing between different lines. Examples of good design are then shown, such as where colour is used but augmented with different line styles and bigger symbols.

Okabe and Ito make the point (stated in several other articles) that the message should remain clear even after black and white photocopying. Like Kaufman-Scarborough, the authors advocate retaining colour in visual communication design, but assert that it must be combined with other communication devices so that colour-blind viewers are not disadvantaged.

Summary of other precedents for patterned colour

The Ishihara Colour-blindness Plates use pattern to communicate selectively with specific audiences or across an entire audience spectrum. The design component of the thesis will employ colour and pattern with the similar intention of communicating inclusively with both colour-blind and non-colour-blind audiences.

Following is a summary of findings from key studies in the field of colour vision deficiency, supported by anecdotal observations from colour-blind people.

The findings indicate that colour should not be used as the sole indicator of information, but should instead be augmented with other recognition clues such as pattern. Confusing colour combinations and low saturation colours should be avoided where possible. In instances where it is important for the target audience to be able to distinguish between adjacent colours, there should be high contrast between them.

Ideally, text should not be placed on coloured backgrounds unless the contrast between text and background is high.

Lime yellow and other 'light' colours afford higher visibility for colour-blind viewers than does the traditional 'alert' colour of red, which is darker-toned. Yellow and blue are, in almost all cases, equally conspicuous to colour-blind and non-colour-blind people.

Finally, placing light-coloured contrasting patterns within ambiguous colours can potentially help colour-blind people to identify them.

Discussion
Informative ornament: Designing the system

Studio research

Development of the system

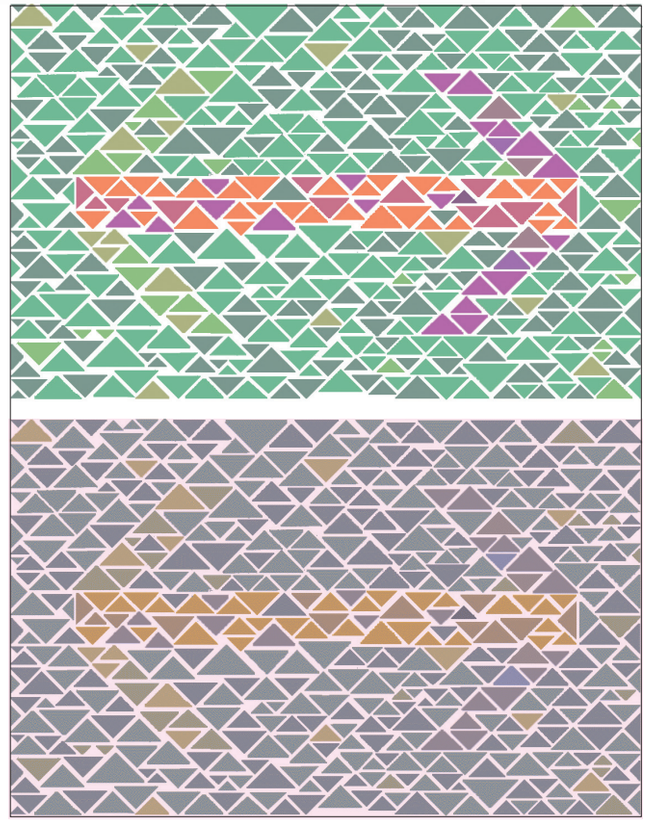
Figure 22: *Studio work with selective visibility.*

The design decisions discussed in this section incorporate conclusions from the previous inquiries as well as from the practical investigations described here.

Before beginning to design the system of patterned colour, I spent a considerable amount of time studying the Ishihara Colour-blindness Plates. According to Eric Kindel, Ishihara painted each of the plates by hand using watercolour paints. These were then translated into print via the lithographic reproduction process (Kindel, 2001, p.20).

I photographed a set of the plates and, using Adobe Photoshop, sampled the colours. Using those colours and others that followed the same principles, I designed a number of images and tested them for their visual effectiveness by putting them through the colour-blindness simulation palettes. I wanted to create, as Ishihara had done previously, images that would be visible to some people but not to others. Although I used the Ishihara concept of arranging shapes into patterns, my initial experiments used non-circular shapes. Figure 22 shows one such example and (below) its colour-blindness-simulation equivalent, in this case for a green-weak viewer.

It became obvious that it was a very difficult task to create an image that would 'fool' viewers with full colour vision. A small number of Ishihara's plates contain images



that cannot be seen by those with full colour vision, but are visible to colour-blind viewers. Ishihara

was obviously very skilled with his watercolours, because I was unable, after much trying, to completely duplicate this effect. However, when I put the relevant Ishihara plates through the colour-blindness simulation palettes, they did not reveal any visible images either, so the effect might be quite subtle.

The closest I came to this effect (Figure 23) was when I used circles rather than angular shapes for the basic units of the patterns. This followed supervisor and peer feedback indicating that triangles and other non-circular shapes were less effective than circles.

On the left is an image that looks to those with full colour vision like a C, while on the right is an approximation of how it would appear to a red-weak viewer – more like a G. Unfortunately, the extra part of the G in the left image is slightly visible to those with full colour vision, so the image is not entirely successful.

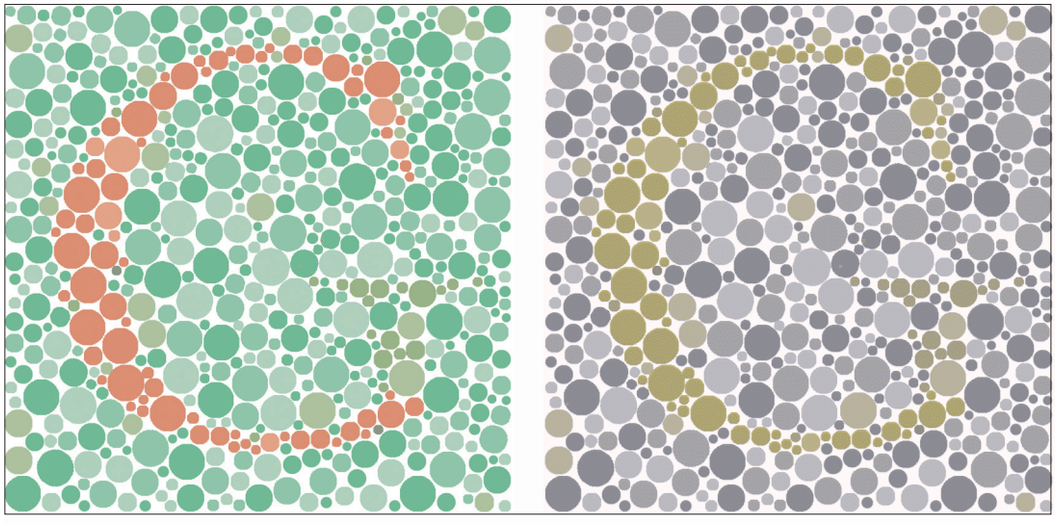


Figure 23: *Studio work with selective visibility.*

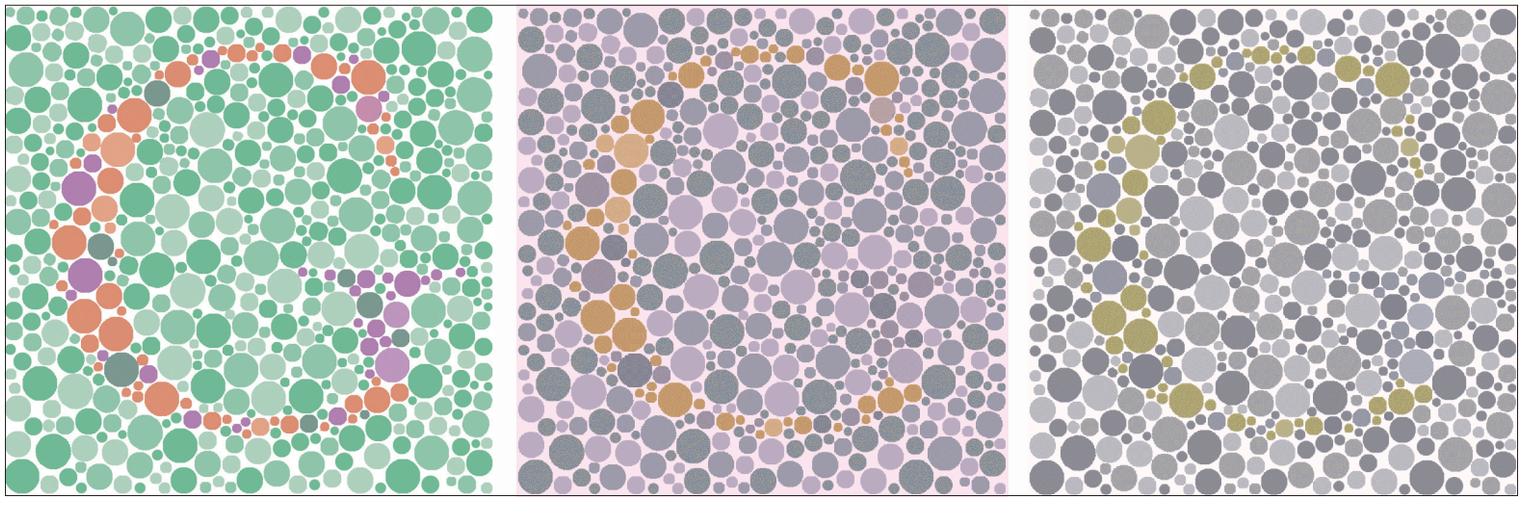


Figure 24: *Studio work with selective visibility.*

Making images that were partially indistinct to colour-blind people was easier. An example of this is evident in the set of images in Figure 24. On the left is the full colour version. In the middle is the same image as seen by a green-weak (deuteranomalous) viewer, and on the right is the image as seen by a red-weak (protanomalous) viewer. The characteristic vertical stroke of the G becomes difficult to see in the colour-blindness simulations.

However, as a result of my reading and my discussions with colour-blind people, I realised that these images would not be indistinct to all colour-blind viewers. It became clear that I could not create images in the picture book that would be visible only to a colour-blind audience. I had to be content with the idea of communicating equally well with colour-blind and non-colour-blind viewers, using the colour principles I had gleaned from Ishihara's plates and other sources.

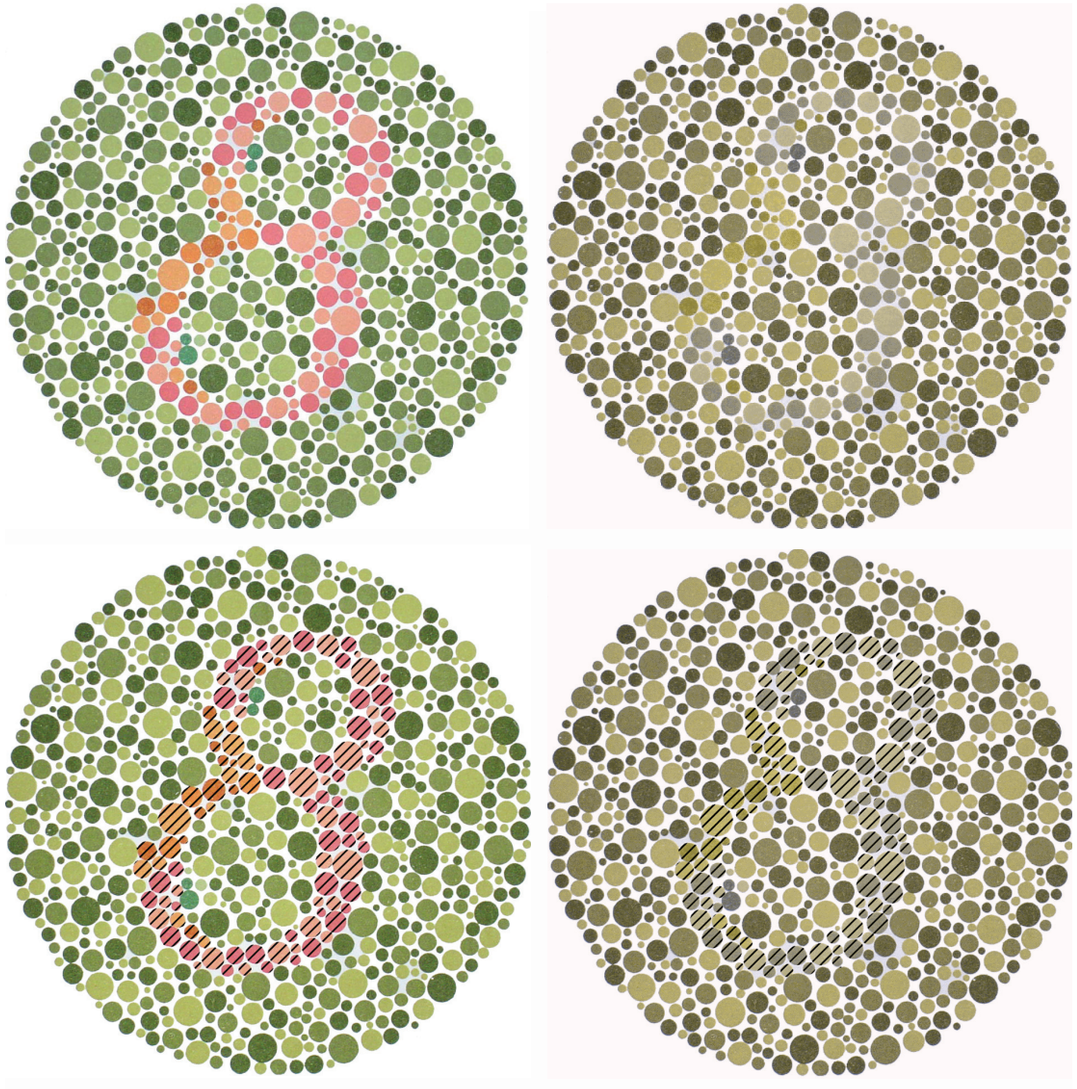


Figure 25: *Ishihara's Plate 2 without and with patterned colour, and colour-blind equivalents (as for a red-weak viewer).*

Patterned colour

The next step was to create a set of images that could test the efficacy of patterned colour. It seemed logical to begin with Ishihara's plates for these also.

Figure 25 shows an example of patterned colour inserted into

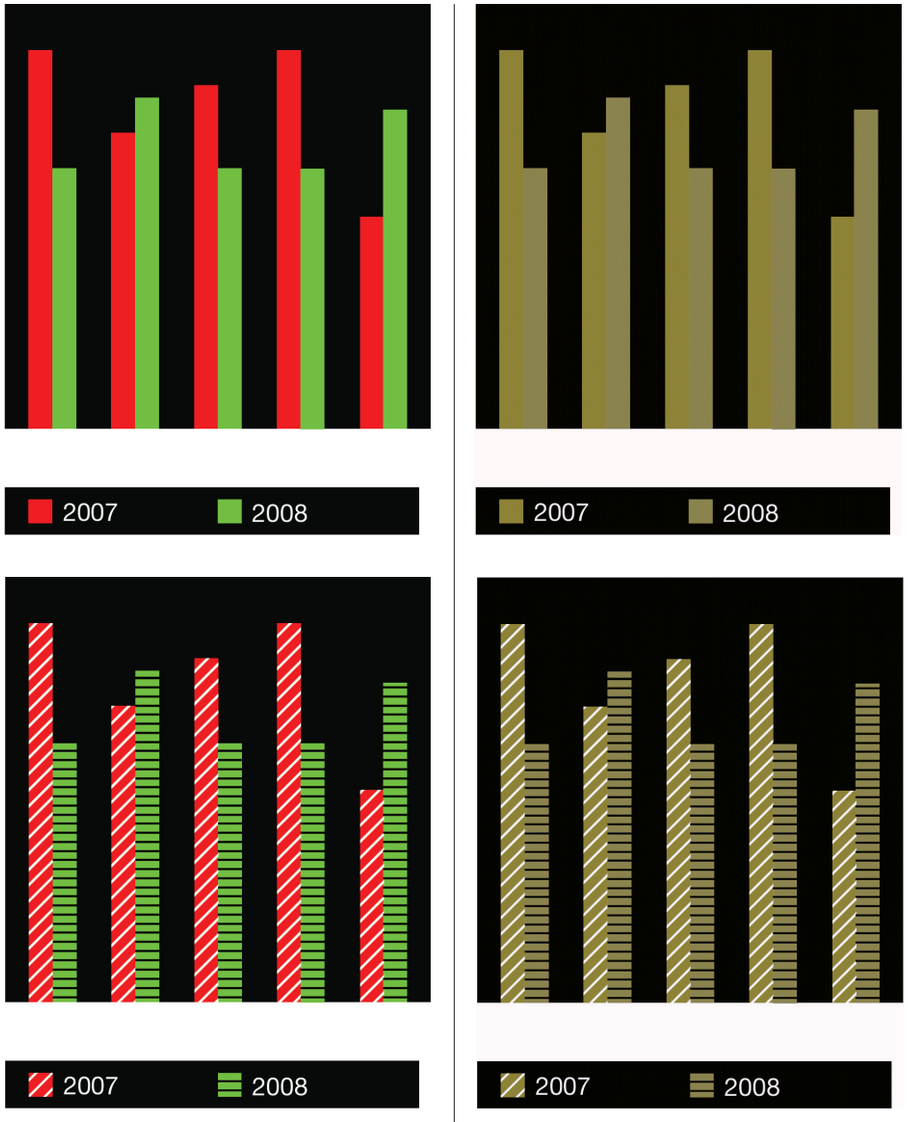


Figure 26: *Patterned colour applied to a simple graph.*

an Ishihara plate. At the top left is Ishihara's Plate 2, which for those with full colour vision shows an 8. For most colour-blind viewers it shows a 3; this is represented in the top right image, which is a simulation of how Plate 2 would be seen by a red-weak viewer. At the bottom left is a version of Plate 2 in which red tones have been embedded with a pattern of diagonal lines. At the bottom right is this same image as it would be seen by a red-weak viewer. This set of images suggests that pattern could make the red hues of the original plate more visible for colour-blind viewers.

I made a number of pairs of such images, with and without patterned colour. In some cases I created a third version in which the patterns were light rather than dark. As the design research progressed I found more and more evidence suggesting that the pattern within red should be of a light colour, possibly even white. This is because for red-weak and red-blind individuals, red appears relatively dark. Red-blind individuals are especially disadvantaged in this respect, because the red cones usually comprise 60% of the total number of cells. When these cones are missing, the ability to gather light rays is considerably reduced.

Figure 26 demonstrates the

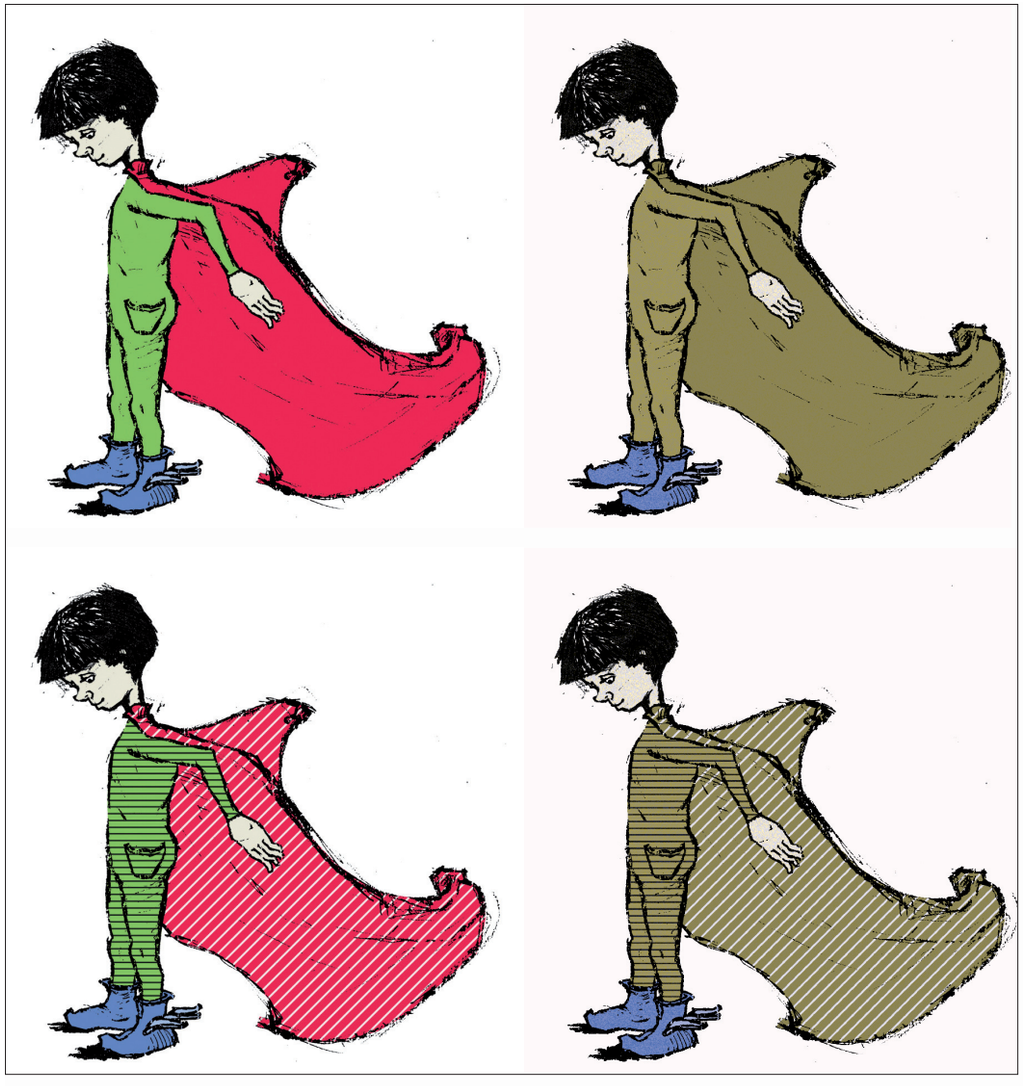


Figure 27: *Patterned colour applied to illustrations.*

use of white diagonal lines within the colour red. The top left and bottom left images show a graph without patterned colour and with patterned colour respectively. At the top and bottom right are their corresponding simulations for a red-weak viewer.

Following these trials I moved on to incorporating patterned colour into more complex designs. Figure 27 shows an illustration design that was adapted from an earlier illustration project. The original colours of the illustration were replaced with red and green, and in shades that would look similar to most colour-blind viewers. The top left and right images demonstrate this application and show the full colour version and the red-weak simulation respectively. The bottom images show (left) the illustration embedded with patterned colour and (right) its corresponding red-weak simulation.

Figure 28: *Later form of the pattern for red.*

As the design of the picture book progressed, it became evident that the impact of the story could be enhanced if the patterns were invested with narrative significance. I speculated that each pattern could reflect some aspect of

the story. For example, a maze-like pattern could allude to an episode where the main character was trapped in a maze.

I also theorized that the patterns could be designed to incorporate semiotic meaning. For instance, diagonals could be used to signal 'cautionary' concepts commonly associated with the colour red.

As a result of this thinking it became necessary to make the embedded patterns more complex. Figure 28 shows one of the outcomes of this design process.

The images

The studio work resulted in twenty-three images for testing. Three further images were added. These were examples of everyday visual communication design, found in the course of the research, that were considered likely to cause visual confusion for colour-blind viewers. They were included in order to obtain feedback about this.

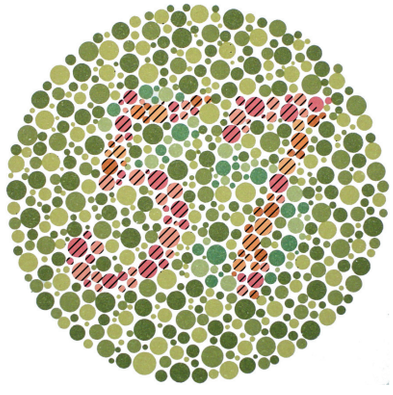


Figure 29 *Aa.jpg*.

The names of the twenty-six images were coded where appropriate, to avoid giving any clues about what the participants 'should' see in them. Also, pairs of images for which a participant's responses would be compared were separated in the booklets in which they were presented (see *Ethics approval and testing*). This was an attempt to prevent participants from comparing pairs directly; respondents were also asked to avoid such comparisons.

The following lists the complete set of images that were sent to survey participants.

Aa.jpg (Figure 29) is an Ishihara plate with dark diagonal patterning embedded into the red number. *Boy 1.jpg* (Figure 30) is an illustration with no patterned colour, while *Boy 2.jpg* contains simple patterned

Figure 30: *Boy 1.jpg*, *Boy 2.jpg* and *Boy 3.jpg*.

colour. In contrast to *Boy 2.jpg*, *Boy 3.jpg* is embedded with a more complex pattern.

Bush scene 1.jpg and *Bush scene 2.jpg* (Figure 31) compare the efficacy of a red bush marker with and without pattern.

Cc.jpg (Figure 32) shows another Ishihara-based plate, in which the green circles have been embedded with dark horizontal stripes. *Fruits 1.jpg* and *Fruits 2.jpg* (Figure 33) compare two

Figure 31: *Bush scene 1.jpg* and *Bush scene 2.jpg*.

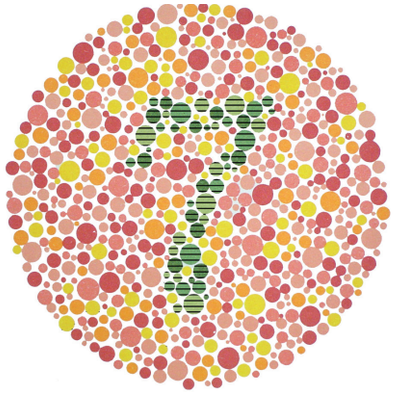
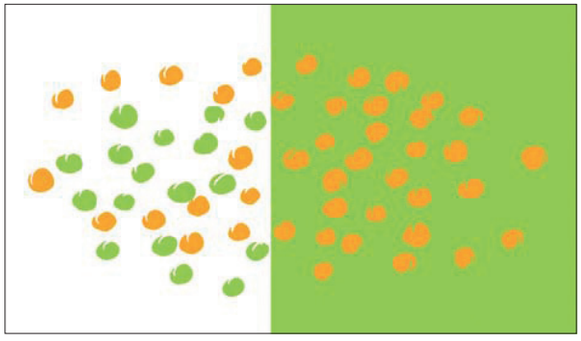


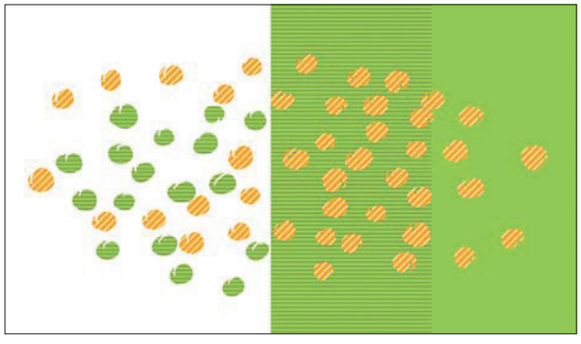
Figure 32 (below): *Cc.jpg*.

illustrations that contain small areas of colour, with and without pattern.

Gg.jpg (Figure 34) is another Ishihara-derived plate, and is designed without pattern. It makes a pair with *X.jpg*, which contains pattern. *Graph 1.jpg* and *Graph 2.jpg* (Figure 35) use colours that often confuse colour-blind people, and compare the recognisability of patterned and non-patterned colour.

Hh.jpg (Figure 36, top) is an Ishihara-based image that features light rather than dark diagonal lines. *Jj.jpg* and *Ll.jpg* (Figure 36, bottom left and right respectively) are light-patterned





and nonpatterned equivalents of *Aa.jpg*.

LM wheel.jpg (Figure 37) represents the colour-coding system

Figure 33: *Fruits 1.jpg* and *Fruits 2.jpg*.

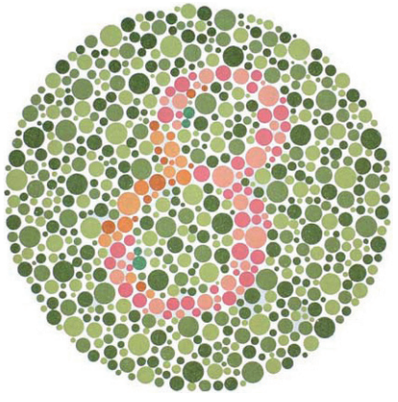


Figure 34: *Gg.jpg*.

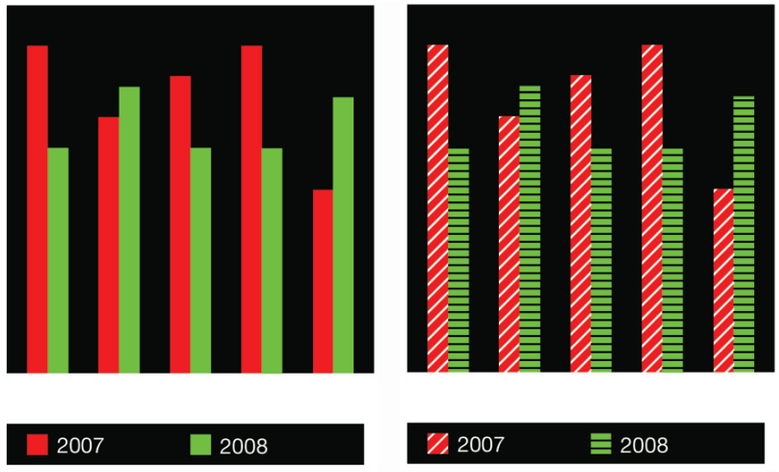


Figure 35: *Graph 1.jpg* and *Graph 2.jpg*.

for a series of instructional reading books published by the New Zealand Ministry of Education.

Nn.jpg (Figure 38) is an Ishihara plate with no embedded pattern that is included for comparison with *Hh.jpg* and *Uu.jpg*.

Pp.jpg and *Ss.jpg* (Figure 39) are patterned and non-patterned versions of the same Ishihara plate, providing a comparison of relative legibility.

Reading rods.jpg (Figure 40) shows part of a commercially available kit designed to improve

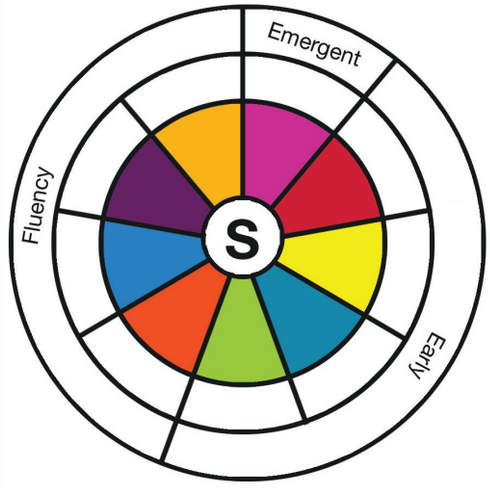


Figure 37: *LM wheel.jpg*. © Ministry of Education, Wellington, New Zealand

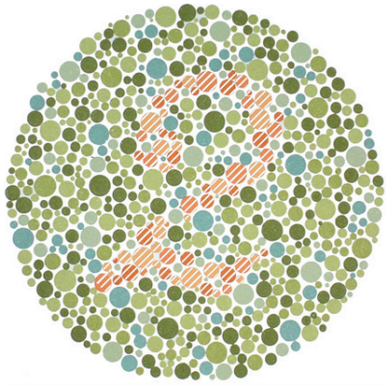


Figure 36: *Hh.jpg, Jj.jpg and Ll.jpg*.

Figure 38 (centre): *Nn.jpg*.

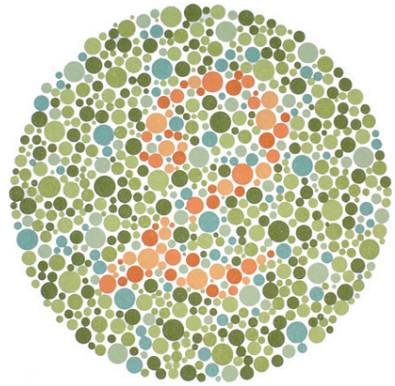
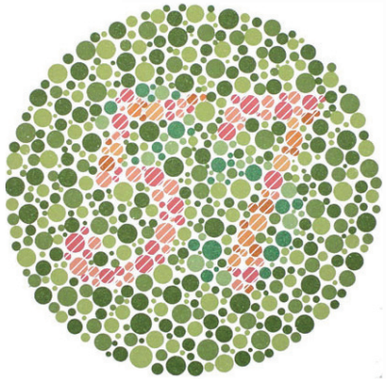
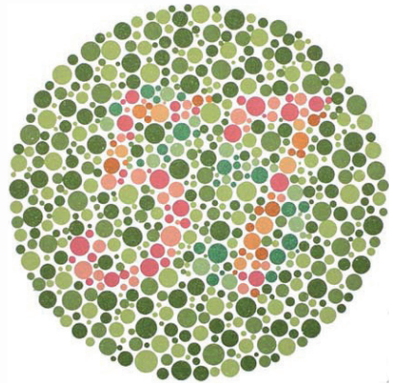
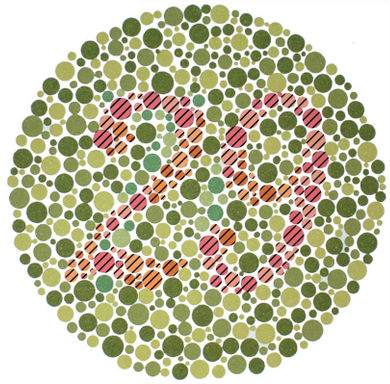
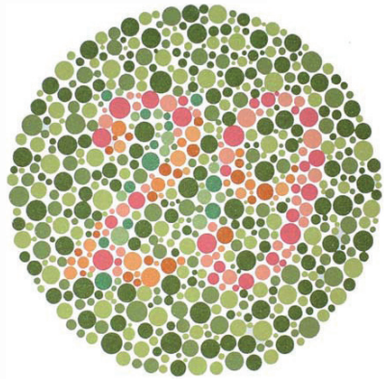


Figure 39 (bottom): *Pp.jpg* and *Ss.jpg*.









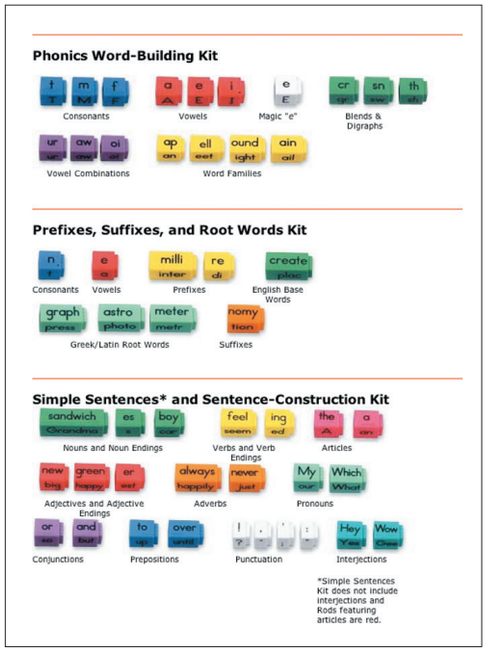


Figure 40: *Reading rods.jpg*.

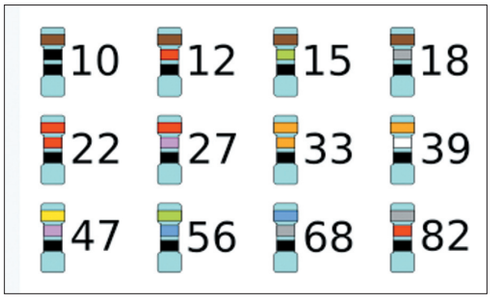


Figure 41: *Resistors.jpg*.

the literacy skills of school children. *Resistors.jpg* (Figure 41) is a chart detailing some of the colour codes used to identify these small electronics components.

Traffic light 1.jpg and *Traffic light 2.jpg* (Figure 42) are designed to investigate whether patterned colour might help colour-blind people to interpret traffic signals more readily.

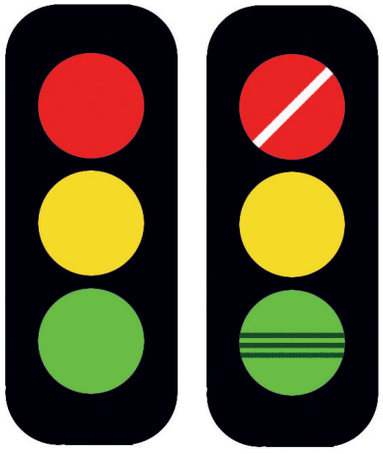


Figure 42: *Traffic light 1.jpg* and *Traffic light 2.jpg*.

In Figure 43, image *Uu.jpg* is the patterned-colour equivalent of *Nn.jpg*, while in Figure 44, *Vv.jpg* is the nonpatterned equivalent of *Cc.jpg* and *Xx.jpg* is the patterned equivalent of *Gg.jpg*.

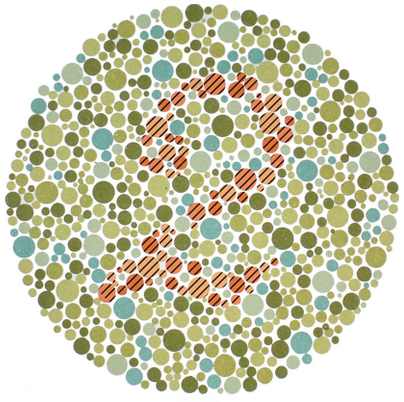
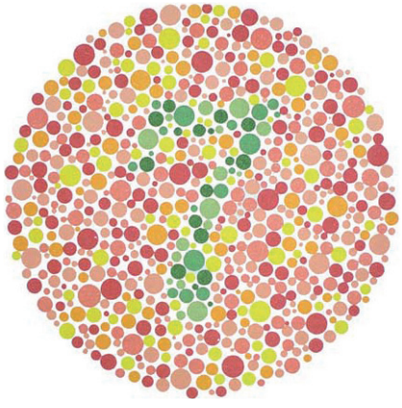


Figure 43: *Uu.jpg*.



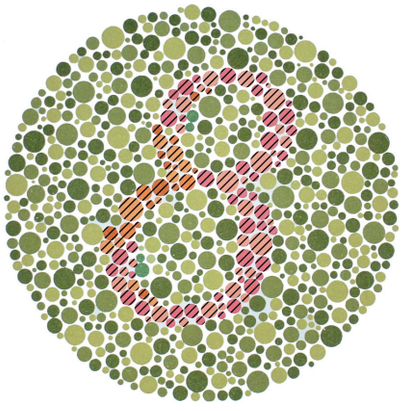


Figure 44 (below): *Vv.jpg* (left) and *Xx.jpg* (right).

Ethics approval and testing

In preparation for the ethics approval process and for testing the patterned-colour images, I had earlier read the Massey University *Code of ethical conduct for research, teaching and evaluations involving human participants* (Massey University, 2009A), and had been instructed in its implications by my supervisors. I had also downloaded and completed the *Screening Questionnaire to Determine the Approval Procedure* (Massey University, 2009B). The questionnaire

results indicated that the proposed research was of low risk.

Having further discussed with my supervisors the results of the *Screening Questionnaire*, I submitted a Low Risk Notification to the Research Ethics Office in Palmerston North. On receiving acknowledgement of this Notification, I sent covering letters and consent forms (Appendix 1) concerning the proposed study to six potential participants. All of those approached agreed to take part.

Each participant was posted a bound A4 folder containing the twenty-six images. Every page in the folder displayed one image and several short questions about it, with spaces below for written responses (Appendix 2).

The participants were asked to record their responses in writing. When the folders were returned by post, these responses were transferred to computer files and analysed.

Results and discussion

The participants' responses are shown in full in Appendix 2.

The twenty-six images can be divided into three groups. These are: those derived from Ishihara plates; those that have been created as examples of 'every-day' visual communication design in which patterned colour could be helpful; and those illustrating existing visual communication design that is considered potentially confusing for colour-blind viewers.

In the first group, consisting of images derived from Ishihara plates, patterned colour aided the identification of colour in every case. Pattern enabled respondents to recognise shapes that were not visible to them in the equivalent nonpatterned plates. In a few instances, respondents were able to recognise nonpatterned shapes, although the shapes appeared to them indistinct. However, in each of these cases they found the patterned-colour versions of the same shapes easier to recognise.

The second group consists of the 'Boy' illustrations, the bush scenes, the 'Fruit' images, the bar graphs and the traffic lights.

For five of the six respondents, patterned colour did not assist colour identification in the Boy illustrations (*Boy 1.jpg, Boy 2.jpg, Boy 3.jpg*). This was because those respondents were already able to identify the colours reliably without the additional cue of pattern.

Four of the six participants found that the white diagonal stripe on the red track marker (*Bush scene 2.jpg*) was visible whereas the red marker without a white stripe (*Bush scene 1.jpg*) was not.

With the Fruit images (*Fruits 1.jpg, Fruits 2.jpg*), three of the six colour-blind people were already able to differentiate among the colours present, so that patterned colour did not aid their perception. The remaining three respondents thought the patterns helped

them to differentiate between the colours more clearly. However, two people noted that the patterns were distracting. One of these two respondents had also mentioned that the patterns in *Boy 3.jpg* were distracting.

This feedback led to some further testing, which is described later in this section.

The results for *Graph 1.jpg* and *Graph 2.jpg* also led to further testing. One person thought the patterns assisted his colour recognition unequivocally. Three others could see the colours anyway, so patterned colour did not help. Two respondents found that pattern helped with red but not with green: it seemed the dark lines were not a good choice there because the green appeared dark already. One participant who could see differences in the colours of the bars found the patterns distracting.

Most of the participants could see the colours of *Traffic light 1.jpg* without difficulty, and so found that the patterns in *Traffic light 2.jpg* did not help with colour recognition. One respondent wrote that the diagonal white line in the red light helped him to identify it as red, but that the dark lines in the green were not similarly helpful. This finding indicates that the pattern in green should be of a light rather than a dark shade.

The third group of images (*LM wheel.jpg, Reading rods.jpg* and *Resistors.jpg*) were included because they were thought to be potentially confusing to colour-blind viewers. These test images elicited some interesting feedback from the participants.

Five of the six respondents had difficulty identifying at least some of the colours on the colour wheel, *LM wheel.jpg*. One person, who identified three of the nine colours accurately, commented that the colours he gave were 'guesses.' Concerning the resistor colours in *Resistors.jpg*, one person wrote that it was very 'hard to list the colours. I'd be guessing other than for white.'

Reading rods.jpg drew the most strongly-worded comments. One respondent wrote that he could not 'read any of the writing on red blocks. Ones labelled vowel combinations [purple] are not much better.' Another respondent remarked that black 'letters on blue, red and purple are EXTREMELY difficult to read. Black on green is hard work but visible. I sincerely hope this hasn't been used as a genuine reading 'aid'.'

As mentioned earlier, some respondents noted that the patterns in the patterned-colour images were sometimes actually distracting. In particular, the closely-spaced white diagonal lines applied to the colour red appeared to have the effect of an optical illusion, and to 'shimmer'. In some cases this actively hindered the participants' ability to see the colours.

As a result of this feedback, I devised some alternative patterns and created a number of test sheets to demonstrate them. These pages illustrated variations not only in the forms of patterns, but also in their

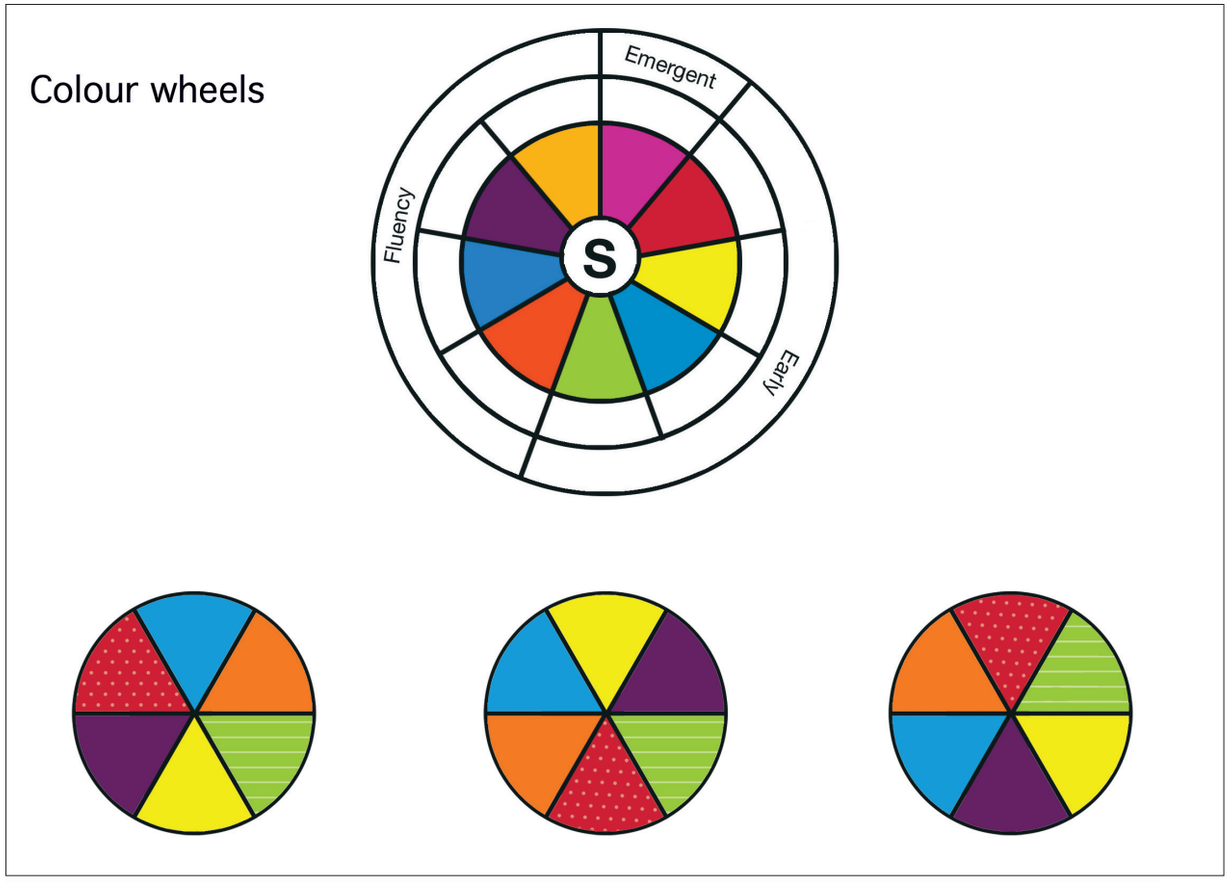


Figure 45: *Colour wheels.jpg.*

brightness. One of the respondents agreed to look at the additional test images, and these were sent to him.

Figure 45 shows one of the test pages. It is a variation on the image titled *LM wheel.jpg* from the original group of images. Here, red is patterned with small dots rather than diagonal lines, and the horizontal lines for green are spaced further apart than previously. Also, both patterns are light-toned but have had their opacity reduced in Photoshop to diminish their brightness.

The participant was told that all segments patterned with white dots were red in colour, and that green segments were patterned with white horizontal lines. He commented that 'the patterns are good – not distracting. This is probably the secret – that the patterns should not be bold, rather they should be muted (if they are a repeated pattern within a colour, as opposed to a single bold stripe across a traffic light).' He also noted that although he could not unequivocally identify all of the colours in the patterned colour wheels, nevertheless the revised patterns allowed him to differentiate among them very reliably. This was evidenced by his labelling the colours consistently as (a), (b), and so on for each wheel. He stated that the combination of the reduction in the number of colours, and the use of patterns, made the colour differences 'very clear' to him.

Another group of tests, one of which is shown in Figure 46, was sent to the same person. This set of images consisted of four pages

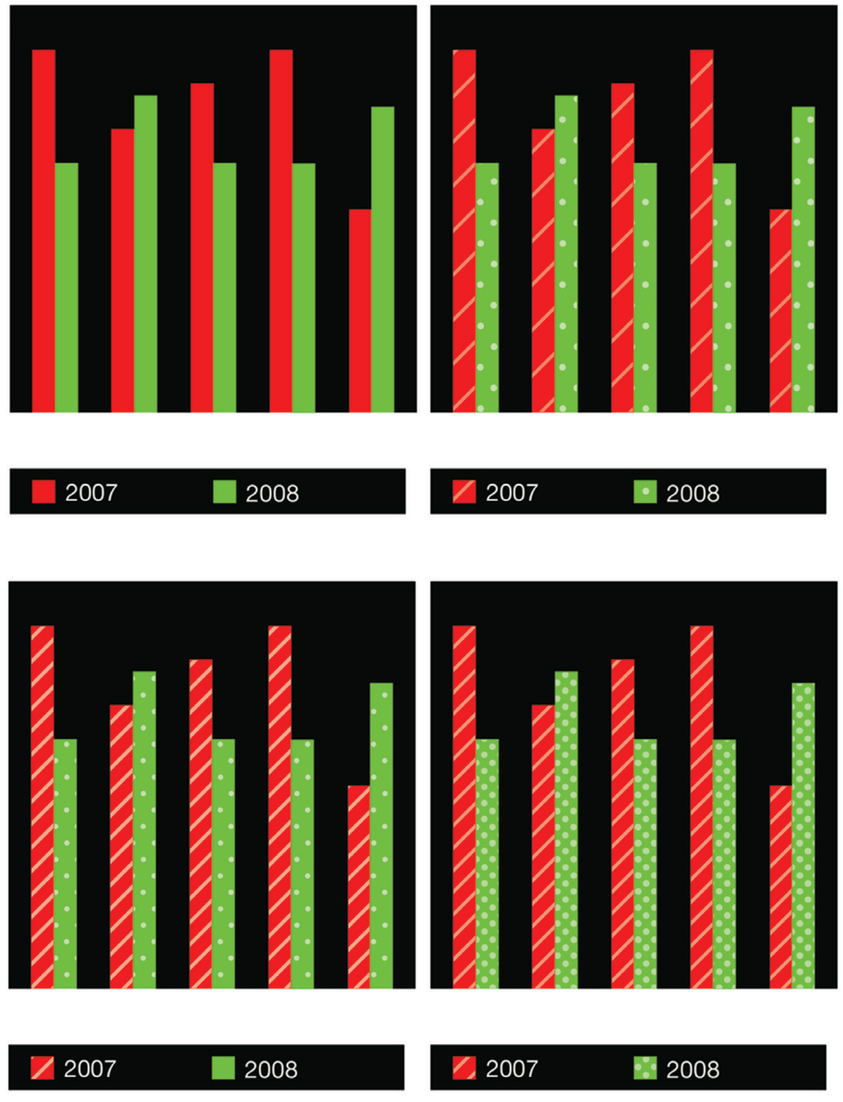
that tested the variables of pattern type, pattern density and pattern brightness. The trial pattern types consisted of dots, horizontal lines and diagonal lines. Pattern density, that is the number of lines or dots per centimetre, ranged from sparse to dense, and brightness was varied among 50% opacity, 70% opacity and 100% opacity.

In Figure 46 the patterns are of 50% opacity. The respondent found that of all such images sent to him, the patterns in the bottom right graph of this figure were of an optimal type, density and brightness to allow him to identify the red and green bars.

In summary, patterned colour appears to have the potential to assist colour identification in many situations. Perhaps the most important of these is in circumstances where safety is important, such as on informational signage. An example is the addition of single light-coloured diagonal bars to red track markers.

Another promising application of the system is in fields that use colour coding. This encompasses a wide range of disciplines, including education, electronics and medicine. The results suggest that much confusion could be avoided through the simple application of patterned colour wherever colour coding is employed.

These findings are indicative only. More stringent testing with a larger group of colour-blind people is required before the efficacy of patterned colour can be confirmed. However, the informal testing carried out here implies that the system could help colour-blind people to reliably recognise colours.



Sheet B: same as A, but patterns are less bright.
Pattern convention for this sheet: red has diagonal lines, green has dots.
Top left: Unpatterned, for comparison.
Top right: dots and diagonal lines spaced out to reduce 'shimmer'.
Bottom left: dots and diagonal lines less spaced out.
Bottom right: dots and diagonal lines close together.

Figure 46: *Sheet B.jpg*.

Discussion
Informative ornament: Designing the system

Summary

The design research indicates a clear need for a visual means by which colour-blind people can quickly and reliably recognise colour. Additionally, the findings identify a requirement for greater public awareness of the visual needs of the colour-blind.

Patterned colour appears to be a solution to the problem outlined in the *Abstract*, namely that visual communication design as it is practised at present does not communicate well with colour-blind people.

There exist numerous precedents for pattern that conveys information, and several of these have been adopted for implementation in the design of patterned colour. Likewise, the design work for *The Machine* has taken into account the many sources of information about visual practices that cause difficulty for colour-blind audiences.

Colour is recognised by artists, designers and theorists alike as having enormous communicative potential. Although this potential is available to visual communication design practitioners, it is limited by the difficulty that colour-blind people experience in identifying certain colours. However, patterned colour has the capacity to extend the communicative potential of colour, by removing the confusion experienced by colour-blind people when confronted with such colours.

As the anecdotes at the beginning of this thesis attest, some of our current visual communication design practices cause colour-blind people to experience visual confusion; and moreover, this confusion can lead to real danger.

I propose that patterned colour, because it offers a way of removing such visual confusion, warrants further investigation.

Discussion
'The machine': Creating the picture book

Design research

Requirements of the book

The picture book *The Machine* is designed to meet several requirements. Most importantly, it has been created to engage a target audience of children aged 5-8 years. I contend that such engagement will foster empathy for the central issue of the book, thus fulfilling a key intention of the thesis.

Another requirement is that the book contains an allegorical message for older readers. In most cases the book will be read with an adult, and if that person understands the story at a deeper level, he or she can convey the meaning embedded in the visual narrative to the child reader.

In addition, the book is intended as a platform for patterned colour. It therefore needs to demonstrate how patterned colour works, by presenting it in an optimal setting.

Finally, the picture book is required to communicate equally well with colour-blind and non-colour-blind viewers. At no point should a colour-blind reader be visually disadvantaged.

Defining the genre

Wordless picture books have existed for a number of centuries, and are now part of mainstream children's literature. *A New Year's Gift: For Little Masters and Misses*, by Thomas Bewick, was published in 1777 (Dowhower, 1997, p.58). In *Every picture tells a story,* Kathleen Collins states that the 'early 20th century produced a robust tradition of books without any writing at all. Such wordless books rely on visual cues to tell their stories, drawing on traditions of wordless story-telling such as pantomime, medieval stained glass windows, African American "story quilts", cartoons, and silent films' (Collins, 2006, p.1).

Lynd Ward, an early twentieth-century artist who specialized in creating 'woodcut novels', was influential in starting this tradition. At the time, his work resulted in a proliferation of wordless books for adults, although it was not until the later twentieth century that picture-stories for children became common. In the 1970s the form started to become more popular, and this popularity increased to the extent

that there are now almost a thousand English-titled wordless picture books in circulation (Dowhower, 1997, p.59).

How exactly is the genre defined? Sarah Dowhower (1997, p.63) describes wordless picture books as

> a literary genre that relates concepts, portrays themes or sequences of ideas, gives information, provides entertainment and interaction, and/or tells a story through a series of illustrations without written text. It is a recent strong genre of books with a wide array of formats and illustration styles appealing to a variety of age levels.

Far from being restricted by its lack of text, the genre of wordless picture books has a good deal of scope and communicative potential.

Precedents for The Machine

Persuasion by picture

The following is an overview of ten wordless picture books selected from the late twentieth and early twenty-first century. All of the books chosen for analysis have enjoyed long-lasting success with both children and adults.

The reason for the selection is to pinpoint the techniques of visual rhetoric employed by some of the best author/illustrators.

To facilitate analysis, the topic of visual rhetoric is divided into categories of narrative, characterization, design elements/ layout and genre. The analyses look for common practices that could inform the design of the thesis picture book entitled *The Machine*.

Window, by Jeannie Baker

1991, Julia MacRae Books, London.

Window is 32 pages in length and is intended for children aged five to ten years.

Narrative: In this story, which is set in an unidentified rural area, a child named Sam is growing up. As he grows the world changes outside his window. At the outset of the narrative, a lone house appears in a patch of cleared forest. After a few years pass there is a village in the distance. The village grows into a city, and eventually the natural environment is lost to urbanisation. Sam gets married and has a child of his own, and moves to the country. On the last page the view is again of a wilderness, but there are clues that the whole damaging cycle of urbanization is about to be repeated.

A short postscript advocates taking better care of our environment. On her web site Jeannie Baker describes *Window* as 'a wordless picture book exploring the concept of exponential change' (Baker, no date).

The narrative is aided by several visual devices. For example, birthday cards show the boy's age changing as he gets older in the illustrations. We learn the boy's name when he writes it on a window in the condensation from his breath.

At the outset the house is isolated in a rural setting, with washing hanging on the washing line outside.

By the end of the story signs of urbanization abound in the form of streets, shops, cars and other houses.

The author makes use of symbolism when the boy, aged seven or eight, aims a slingshot at two pigeons on the roof outside. This device makes reference to the destruction of wildlife that humans are causing all around him. Similarly, the boy chops down and cuts up a tree to make his fort, echoing the building going on around him. The neighbour's tree disappears from its yard, and in the same illustration firewood is being sold across the street. In one illustration, a MacDonald's burger packet, signifying the growth and dominance of international corporations, is left lying on a windowsill.

Characterization: Although we never see the main character face-on except in the distance, Sam is consistently recognizable. He is a 'typical' boy who gets into scrapes occasionally. He wears home-made woollen jerseys that suggest his mother or other family member(s) practise home crafts, which in turn implies alternative lifestyle values and/or restricted access to 'commercial' clothing.

A number of visual clues suggest that the boy is well loved and cared for. He has a teddy bear, a cat and a pet rabbit, and someone has made him a rubber tyre swing in the tree outside.

Design elements/layout: The book is window-shaped to emphasize its title. The colours are primarily earthy and slightly muted, but more red is introduced over time. The use of this symbolic colour signals an increased threat to the wildlife surrounding the new suburb. The collage style incorporates elements like knitting, cloth and leaves, thus contributing to the 'home-made', close-to-nature feeling of the book.

Genre: Window belongs to the genre of educational books. The author is concerned about environmental damage, especially the extinctions of fauna and flora caused by the destruction of the natural habitat.

Slam! by Adam Stower

2005, Templar Publishing, Surrey.

Slam! comprises 32 pages. The publisher's information does not specify a target age group, but promotional material suggests that the book is intended for all ages.

Narrative: A boy slams a door and walks away, unaware of the multiplying consequences of his action.

Apart from the few words at the beginning and end of the story, as well as those describing certain sounds, the narrative is wordless. A number of techniques aid the transmission of the story. These include expressive body language, facial expressions, and hand signals such as a 'shushing' finger to the mouth and hands spread wide to suggest confusion. Similar figurative techniques are used to convey animal expressions, such as when a dog's ears crinkle to show fear.

Characterization: The main character has the body proportions, including the relatively large head, of a younger child. These visual characteristics are

appealing to readers of most ages. While child readers will recognise another child, older readers will generally find the boy's appearance engaging because it triggers their protective instincts. Dr. Maria Alba-Fisch, a registered psychologist working in the New York area, states that 'We are all fundamentally wired to find "cute" creatures appealing' and that 'human and animal babies attract our wish to cuddle, help and protect.' (Alba-Fisch, 2009, para.4).

The central character's other characteristics include shiny hair, baggy clothes and perpetually sagging socks.

The boy's dog has the large head and rotund shape of a puppy, and its visual appeal is further enhanced by a large black nose and floppy ears. The supporting characters, which include a cat, a number of fish, an octopus, a dragon and several circus players, have similarly charming appearances. Thus, by consistently featuring 'cute' characteristics, Adam Stower's illustrations conform to the views expressed by Alba-Fisch.

Design elements/layout: Slam! contains a variety of interesting visual perspectives. Most of the illustrations bleed off the edge of the page, while a few are boxed within a larger illustration. The illustrative elements vary in size from very large in the foreground to small in the background, which adds visual interest. The colour is muted and lacks contrast, which might give colour-blind readers difficulty, and the compositions lack a dominant focal point, causing the reader's eye to wander occasionally. Apart from these factors, the book is visually engaging and strong.

Genre: This book, with its employment of escalating slapstick humour, belongs to the genre of fantasy adventure.

Sunshine, by Jan Ormerod

1981, Frances Lincoln Children's Books, London.

Sunshine comprises 32 pages and is designed for children aged two to six years. It is by the author of *Moonlight*, and predates that book by one year.

Narrative: The main character of this wordless picture book is the same child as illustrated in *Moonlight*. It follows her morning routine from when she gets up and greets her parents, to her independent preparation for kindergarten or school, to the last-minute rush when her parents realise they are late for work.

Young readers will see similarities to and differences from their own morning routines. Again, gentle humour is used at the end of the book.

Characterization: As in *Moonlight*, the main character is shown carrying out activities familiar to the children in the target age group. These include waking her parents (evidently somewhat earlier than they would prefer) and dressing herself. The latter activity is depicted in a sequence of engaging images that would ring true to the target audience. The girl's parents are represented sympathetically but as very human, as when the central character's father almost falls over

while putting on his underwear.

Design elements/layout: Again, almost all of the illustrations are depicted from the child's viewpoint. The illustrative style of line and colour wash is the same technique as was employed in *Moonlight*, and is similarly sympathetic to the subject. Moreover, the same range of design strategies are used to indicate the passage of time.

Genre: This book is gently educational. It illustrates scenes that most child readers can recognize from their own lives, thus teaching them that other children have similar experiences.

Moonlight, by Jan Ormerod

1982, Frances Lincoln Children's Books, London.

Moonlight is also 32 pages long, and is aimed at children aged four to six years.

Narrative: A little girl, after going through her night-time routine, goes to bed and becomes frightened of the dark. She runs repeatedly to her parents, eventually falling asleep but leaving her parents exhausted.

The book illustrates a simple idea that is familiar to many, and therefore needs relatively little explanatory support. The narrative is aided by the sequential illustrations and by the expressions and body language of the main character.

Characterization: The little girl in this story is recognizable to the target audience. She has qualities and characteristics typical of this age group, such as caring for her soft toys and becoming frightened by a story. Her parents are affectionate towards her, and her surroundings and belongings show that she is well loved. Her walls are hung with examples of her own art work, and she has books and toys. The line and colour wash illustrations are applied in a soft style that emphasizes the appeal of the characters.

Design elements/layout: Almost all of the illustrations are depicted from the child's viewpoint. The passage of time is represented by the separation of the illustrations into boxes. The illustrations are varied in size, thus preventing visual monotony, and visual variety is further enhanced by objects sometimes pushing out of the sides of these boxes. Areas of white space are employed to avoid visual clutter.

Genre: Moonlight is an 'issues' book. The story is about a common childhood concern, namely fear of the dark. It is aimed at young children, perhaps to help them realize that other children have the same fear. It employs gentle humour and is intended to appeal also to parents, who might recognize their own role in the story.

You can't take a balloon into the Metropolitan Museum, by Jacqueline Preiss Weitzman and Robin Preiss Glasser

1998, Puffin Books, New York.

You can't take a balloon into the Metropolitan Museum is 40 pages in length and is intended for children aged four to eight years.

Narrative: A young girl is not allowed to take her balloon into the Metropolitan Museum in New York, so she entrusts it to the care of a museum guard. A pigeon untethers the balloon from the railing where it is tied, and the balloon flies skyward. The guard and an increasing retinue of followers pursue it through numerous adventures while the girl and her grandmother explore the Metropolitan Museum.

The book contains images of art works from the Museum's collection, photographically reproduced among the hand-drawn illustrations. The scenes in these art works are often analogous to the experiences of the guard, as he chases the balloon through increasingly chaotic scenes.

The guard and balloon finally arrive back at the museum just as the girl returns to claim her possession.

The narrative is easy to follow. It is aided by illustrations of body language and facial expressions, which are sometimes shown in close-up to aid communication. The passage of time is indicated through sequential illustrations, of which there are often three or more per page.

Characterization: The main character appears to be about eight or ten. She is characterized as a lively child who is interested in the art works at the museum. Her actions and those of her grandmother, who are two of the three main characters, indicate that they have an affectionate relationship. The museum guard is portrayed sympathetically but rather comically as he follows the balloon through New York. The supporting characters are visually interesting, and are representative of both genders as well as differences in age and ethnicity.

Design elements/layout: In general the illustrations are individually boxed. Sometimes they encompass the whole page, but more often there are several per page. Although the pen and ink drawings are detailed and the compositions complex, the use of spot colour guides the reader's eye to the important parts.

Genre: This book is educational, in that it depicts art works from the Metropolitan Museum and scenes from New York City. However, its use of fantasy and humour locate it also in the genre of humorous fantasy.

Clown, by Quentin Blake

1995, Jonathan Cape, London.

Clown comprises 32 pages and is classified as juvenile fiction.

Narrative: A toy clown is thrown away, along with several other toys, into an outside rubbish bin. The toy asks passers-by for help, but is thwarted by the unkindness of adults. It then finds and befriends a girl and her baby brother, and bargains with them that he will help them if they help him. Through co-operation they improve each other's lot. The narrative flow is aided by occasional visual thought bubbles or speech bubbles and by body language, the latter including gestures such as a finger pointing high to signal an 'aha' moment.

Characterization: The clown has large eyes and is the size of a small child or a pet. These traits

are suggestive of a young and vulnerable creature and, as discussed previously, tend to evoke a solicitous response in readers of most ages. Quentin Blake has exploited this response as a way of lending charm to his main character. This charm is further enhanced by the clown's quirky, exaggerated facial and body expressions and its plucky nature.

The tradition of unspoken communication specific to clowns makes this an ideal character for a wordless picture book. In using a clown, the author enlists the conventions traditionally associated with this figure, including mime, humour and pathos, bright colours, and magic. Such associations add richness and authenticity to the story.

Design elements/layout: As with all of Blake's illustrated books, white space is used generously to set off the drawings. The illustrations are executed in Blake's trademark sketchy pen-and-wash style. Their formats vary from boxed to free-floating and from vignette to full-page. This and the variety of size and framing ensure that the design has visual interest and rhythm. In this wordless book the passage of time is indicated by the use of sequential images.

Colour symbolism is a feature of the book. Towards the end of the story a bright pink sunset lifts the previously muted mood, thus suggesting hope, while the happy ending is emphasized by large areas of bright yellows, oranges and greens.

Genre: Although this picture book is clearly a fantasy, it also contains the moral message that helping others can lead to their helping you. Although the message is not presented in a didactic manner, the story could nevertheless be called a modern fable.

The Snowman, by Raymond Briggs

1978, Random House, New York.

The Snowman is 32 pages in length and is directed at children aged four to eight years.

Narrative: A boy builds a snowman. That night it comes to life and the two of them embark on a series of adventures. These begin with the boy introducing the snowman to many of the household appliances, with surprising and gently humorous results. Later the snowman takes the boy on a magical excursion to a distant city before returning him to his home. The snowman then takes his place on the snowy front lawn and the boy returns to his bed. In the morning the snowman has melted.

The passage of time is clearly indicated in sequences of images that range in number from twelve per page to one per double page spread. The visual narrative comprises 175 frames in total. The progression of the narrative is aided by this comic-book format and by the characters' body language, hand gestures and facial expressions.

Characterization: The boy appears to be six or seven years old, and has an engagingly serious facial expression. His behaviour reveals him to be hard-working and persistent in

his task of making the snowman: he takes breaks only for food until the construction is complete.

The figure of the snowman is soft and rounded. When he comes to life he is very polite, shaking hands and doffing his hat in greeting. He takes child-like pleasure in playing, for instance pulling the paper towel roll and skate-boarding, but is vulnerable to flames and heat. His habitual trusting and expectant look is accentuated when he is being fed by the boy. By returning the boy home safely when sunrise approaches, he shows himself to be protective and trustworthy.

Design elements/layout: The design consists of a sequence of unframed full colour images in a variety of sizes. Sometimes there are three small illustrations per line, sometimes one medium and one small, and sometimes one full-width illustration. As the story unfolds and nears its climax, the illustrations spread over half a page. When the snowman takes the boy on his flying adventure the illustrations get larger still and, at the climax, become double-page spreads. After the climax and as the story moves to its ending the images become smaller again.

The illustrations are rendered with coloured pencils in a soft, textured style. Raymond Briggs' use of colour varies according to the setting. Inside the boy's house the colours are warm and relatively unsaturated, hinting at the comfort of the house. In contrast, during the climax of the story the colours are cooler and more saturated, thus suggesting the excitement and intensity of the characters' aerial adventure.

Genre: This book belongs to the fantasy genre, but also has elements of fable. Like *Clown*, it contains the moral message that good deeds are rewarded. The book's imprint page summarizes the story this way: 'When a snowman comes to life, a little boy invites him home and in return is taken on a flight above beautiful cities and strange lands.'

Leaf, by Stephen Michael King

2008, Scholastic Press, Sydney.

Leaf has 64 pages and is designed for children aged four years and older.

Narrative: A boy refuses to have his hair cut and as a consequence, a plant grows in his hair. The boy and his dog manage to keep it alive in spite of parching sun and other hazards. Eventually, his mother insists on cutting his hair, plant and all. The boy then puts the plant into soil and tends it, and it grows into a tree. He continues to visit it over many years, eventually taking his family to see it. The cycle begins to repeat when a seed from the tree falls on one of the descendants of the dog.

The development of the narrative is assisted by sequential illustration techniques and by the body language, facial expressions and hand and arm gestures of the main characters.

Characterization: The main character, a boy of perhaps eight or nine years, is depicted with a large head and thin and vulnerable-looking limbs. He is characterized as

having a love of plants and so goes to great lengths to protect the plant in the story. The dog has a round, puppy-like body and uncoordinated limbs. The other main character, the boy's mother, is portrayed through her behaviour and clothing as slightly menacing.

Design elements/layout: The sequential illustrations are rendered in pen and wash and vary in size, treatment and layout. Some illustrations are framed while others are not, and some have coloured backgrounds while the remainder do not. As a consequence the story is rhythmic and avoids visual monotony.

The author uses colour symbolism to strengthen the message contained in the story. For most of the book the colours are natural greens, browns and blues. When the boy's mother is shown, however, her appearance is always accompanied by the colour purple. When she succeeds in cutting her son's hair so that he walks away with shaved head and broken heart, this hue dominates the illustrations. Once the boy puts the plant in the ground, the purple disappears and earthy colours return.

Genre: This story is a fantasy, but incorporates the message that preserving our environment can bring lasting pleasure.

Anno's Italy, by Mitsumasa Anno

1978, The Bodley Head, London.

Anno's Italy is 48 pages in length and is directed at children aged nine to twelve years.

Narrative: A man buys a horse and travels through Italy. The reader follows him through scenes of Italian life, both past and present. Contained within the central narrative are literary allusions such as a reference to *Alice in Wonderland*, and an illustrative thread depicting the life of Christ as it was portrayed by Italian religious painters of the Renaissance period. The traveller's journey also incorporates historical references to activities such as wood harvesting and house building.

The story reaches its climax in Venice, and here many of the city's iconic buildings are illustrated. The central character then travels on to the coast and sets off across the sea, leaving his horse behind.

The forward momentum and action of this narrative is aided by the fact that the story is a journey. This strong impetus behind the narrative permits Mitsumasa Anno's whimsical mixing of times and his inclusion of fictional elements such as well-known fairy tales. An example of this is the image that portrays a plague-ridden town with Xs inscribed over the doors (perhaps illustrating the Italian Plague of 1629–1631), but also an anachronistic bicycle and a bookshop with *Anno's ABC* in the window.

In his postscript the author/illustrator states that he believes people to be the same everywhere, and consequently hopes that readers of all nationalities will understand his book. 'Though language, letters and customs differ between Europe and

Japan, there are no differences at all in our hearts when we shed tears at parting' (Anno, 1978, postscript).

Characterisation: The travelling man is always recognizable by his clothing, his upright stance and his horse. Other characters are generally seen only once, but their activities are illuminated by their body language and gestures as well as by their vocations, which are made clear by their clothing and tools. A typical example of this form of character convention is where a shepherd is identified by his robe and crook.

Design elements/layout: In this picture book each double-page spread is designed as a single image that bleeds off the page. The traveller moves from left to right across each spread, moving past scenes that catch the reader's eye. The illustrations are executed in ink pen and colour wash, and provide the reader with a good deal of quirky detail.

Genre: The author/illustrator's mixture of fact and fiction and his belief in the universality of human experience impart this book with an educational message. *Anno's Italy* is a fantasy with an informative slant.

The Arrival, by Shaun Tan

2006, Lothian Books, Melbourne.

The Arrival comprises 128 pages and is classified as young adult fiction.

Narrative: A man leaves his country of origin to find a better life for his family. The place in which he arrives is initially unfamiliar and intimidating, with monumental Art Deco-like architecture and bizarre plant and animal life. The immigrant is befriended by a small animal and with the additional help of the locals, gradually adjusts to his new culture. He meets other immigrants who recount their own stories. After a long period of waiting and anxiety on the man's part, his family arrives and he introduces them to their new world.

The Arrival employs both visual metaphor and colour symbolism. The man's experiences in his new country constitute an extended visual metaphor for the experiences of migrants everywhere. The unfamiliarity of the new place is emphasized by its imposing architecture and fantastical life forms.

In some parts of the narrative fantasy stands in for real-life evil, as when invading forces are depicted as skyscraper-sized humans wielding vacuum-cleaner-like machines. Moreover, the invented hieroglyphic language of the new country puts the reader of *The Arrival* into the same situation as a new migrant faced with learning a foreign language.

The creature that befriends the man is a small dog-like animal. According to Shaun Tan, this character represents the idea of belonging in a place (Tan, 2007).

Like Briggs, Tan is a master of sequential illustration. He indicates the passage of time via a number of ingenious visual techniques that include the repetition of similar images. One of the double-page spreads in *The Arrival* features numerous images of clouds, suggesting the passing of many days or weeks. In another spread, the

changing form of a single leaf indicates a progression from spring to winter.

The advancement of the narrative is also facilitated by the key and supporting characters' body language and facial expressions. A raised finger signifies 'note this', while widely-spread hands denote confusion and thumbs up, approval.

Characterization: The central character of *The Arrival* is the immigrant. This character is portrayed as a courteous but serious man who is occasionally overcome by his worries, especially about the family he has left behind. His friendliness to others results in his making a number of friends. He is depicted as trying honestly to adjust to his new country and its social and cultural codes.

The Arrival contains numerous supporting characters, who represent a wide range of human types and races. Their shared immigrant status appears to draw them together into acts of mutual care. Collectively, the characters' behaviour convincingly illustrates the sense of displacement felt by immigrants in a foreign country.

The characterization of some of the 'evil' characters in *The Arrival* is aided by Tan's use of association. For example, the vacuum-wielding giants that are portrayed by Tan as sucking people into their machines function in the narrative as a visual metaphor for historical acts of genocide.

Design elements/layout: The 'realistic' illustrations in *The Arrival* are executed using graphite pencil. They are composed on the page as if in a photograph album and are rendered to simulate the photographic effect of sepia, thus conferring an aged feeling to the book. The juxtaposition of this visual treatment with the fantastical content is unsettling but absorbing.

Tan uses the visual strategy of mimesis for two different types of images appearing in the book. Images that refer to flashbacks look more precisely like old photographs. They appear time-worn, with ragged torn edges, folds and creases. In contrast, images that represent the present are unframed and less worn looking, although they still have the general appearance of photographs.

In addition, subtle contrasts of tone and colour, and a variety of panel sizes and shapes, contribute to the superb visual variety of this picture book.

Genre: By using fantasy in a metaphorical way, *The Arrival* depicts an experience common to many people. Through the visual narrative and design of the book, Tan communicates his belief that being an immigrant is an experience requiring bravery and perseverance.

Although his book is ostensibly intended for young adults, the author/illustrator Tan says he does not write for any specific age group (Tan, 2007). While younger readers might not appreciate the symbolism inherent in the narrative, they would most likely enjoy the other-worldliness and quirkiness of its images.

Summary of the analyses, with additional information from literature

Narrative: In *Narrative as experience: the pedagogical implications of sympathizing with fictional characters,* Howard Sklar states that the simple act of telling a story can create empathy: 'particular components in fiction can contribute to persuading readers to feel sympathy... toward fictional characters...' (Sklar, 2008, p.484).

In 2001 Dr. Robin Mello conducted a qualitative study to investigate North American children's reactions to the oral storytelling of traditional narratives. Mello found that storytelling

> stimulated sympathetic responses... Students often spontaneously discussed their empathic responses after listening to stories. This was probably because, as Egan posits, stories and storytelling required them to actively engage in content by using both their emotional intelligence and their cognitive ability. (Mello, 2001, p.1)

In addition, Kieran Egan (in Mello, 2001, p.1) claims that 'stories, both in format and presentation, are essential [...] tools for teaching and learning'. Mello reinforces this finding by stating that

> By participating in storytelling, the children in this study created transactional experiences that increased their knowledge of self and others. They did this by reflecting on images and conditions in stories and linking them to known cultural concepts and paradigms. Therefore, storytelling needs to be understood as a way of knowing, and as such, we need to recognize it for the valuable educative tool that it is (*ibid.*).

These studies suggest that storytelling, oral or otherwise, is a potent teaching tool. Moreover, the genre of the fairy tale is particularly appropriate for captivating child readers. Egan (1999, p.35) maintains that the 'classic fairy tales [...] have a considerable power to engage young children in Western cultural settings'.

Despite their lack of words and text, the majority of the picture books analysed for this thesis incorporate characteristics of the fairy tale genre. The stories that are less like fairy tales (*Window* and *Sunshine*, for instance) nevertheless possess some features common to that genre. An example is the presence of engaging characters that promote empathy.

The analyses revealed that wordless picture books, especially those aimed primarily at young children, should not be laden with intricate narrative ideas. The books analysed generally impart simple story ideas. The two exceptions are *Window* and *The Arrival*, each of which convey relatively complex and abstract ideas.

The ten books collectively demonstrate a number of techniques that enhance narrative impact. These techniques include visual metaphor (*Window, You can't take a balloon into the Metropolitan Museum, The Arrival*), symbolism – particularly colour symbolism (*Window, Clown, The Snowman, Leaf, The Arrival*), journeys

as narrative devices (*Slam!, You can't take a balloon into the Metropolitan Museum, Anno's Italy*) and the use of fantasy to question social or other norms (*The Arrival*).

Moreover, the books surveyed deal with themes of particular relevance to their target audiences. These include the all-important large versus small (*The Snowman*), power versus powerlessness (*Leaf, The Arrival*), fear (*Moonlight, The Arrival*), and independence (*Sunlight*).

Characterization: In general, the picture books analysed display strong characterization, with the author/illustrators using a variety of approaches to achieve this. Without exception the books' creators make use of expressive figurative characteristics such as body language and facial expression. Similarly, they use their characters' deeds to reveal particular character traits pertinent to the narrative. Some enhance characterization through the use of character conventions, where a few defining features are employed to suggest a stereotype (*Slam!, You can't take a balloon into the Metropolitan Museum, Clown, Anno's Italy)*. In the main, the author/illustrators surveyed use several or all of these techniques simultaneously.

Design elements/layout: Wordless picture books are dependent on visual clues for communication, and consequently the visual portrayal of time passing is especially important. The books reviewed convey the passage of time in a range of ways. Most often it is through some form of sequential illustration, but in the case of *The Arrival* this is overlaid with an ingenious photograph-album device that, while contributing to the historical flavour of the book, reinforces the idea of time passing.

At times, continuity of background colour is used to assist the reader in following the narrative sequence (*Sunshine, Leaf*). In the majority of the books, the device of the close-up is employed to illustrate important moments or significant expressions.

Three of the books use empty space to influence the reader's perception of events. A small illustration in a large area of empty space (*Clown, Leaf, The Arrival*) can suggest isolation and fear. In contrast, Mary Brown, who teaches children's literature at Southern Connecticut State University, contends that a lack of empty space can evoke a claustrophobic feeling (Brown, 2000, p.1). The lack of space is exploited to great effect in *The Arrival*.

In several of the books (*Window, Slam!, The Arrival*), the sizes of illustrative elements are manipulated to alter their apparent importance. Large foreground objects in a composition tend to attract our attention, while those in the background receive less notice. The stratagem of varying the size of illustrative components also contributes to visual variety.

Visual interest is further enhanced in some cases (*Slam!, Clown, The Snowman* and *The Arrival)* by the use of diagonals and strong lines, which can add drama to illustrations.

Genre: Brown (2000, p.1) suggests there are many rewards for creators of children's fantasy fiction. She maintains that this genre enables authors to explore complex ideas on a symbolic level, and furthermore, it allows them to challenge their readers' perceptions of reality while simultaneously developing the imaginations of those readers.

Wordless picture books seem to be less well-equipped than written fiction for conveying involved ideas. Nevertheless, several of the books studied (*Window, Leaf* and *The Arrival*) succeed in communicating complex concepts to their target audiences.

Of the ten books analysed, seven are fantasy tales. This genre is well-suited to stories that seek to teach something in particular (*Anno's Journey*), or highlight something about the world (*The Arrival*), or question existing attitudes (*Clown*). Moreover, by combining reality with fiction, the genre of fantasy allows its creator to challenge situations that exist in real life.

Seven of the ten picture books incorporate fairy tale elements, such as magical happenings (*The Snowman*), good characters combating evil (*The Arrival*), physical transformation (*Leaf*), and journeys of discovery (*Clown*).

Two of the books, *Window* and *Anno's Journey*, contain overt educational messages. In the postscript to *Window*, the author states that 'by understanding how change takes place and by changing the way we personally affect the environment, we can make a difference' (Baker, 2002, postscript). *Anno's Italy* also contains a postscript expressive of the author's view that 'there are many more things in common than things that differ. [...] I am certain that everybody who looks at [this book] will be able to see what the people in it are doing and thinking' (Anno, 1978, postscript).

Several of the other books surveyed also have didactic qualities, although they are less obvious. *Clown* teaches that cooperation can result in benefits for all. *You can't take a balloon into the Metropolitan Museum* informs its readers about particular art works held in the Museum's collection, while *The Arrival* shows its readers the bewilderment and awe that migration to a foreign country can provoke.

Of the titles surveyed, those that are most successful have certain features in common. These wordless books are primarily fantasy tales that include fairy tale elements. In the main, their narratives address themes of particular relevance to their target audiences. Often they involve a journey of some kind, which involves showing the passage of time through sequential narrative. Typically, characterization is achieved through the expressive figurative treatment of the characters, and sometimes this is enhanced by the use of visual metaphor, colour symbolism and symbolic association. In all cases the design elements of line, colour, scale and space are employed to great effect.

All of these features will be considered in the design of the picture book *The Machine*.

Discussion
'The Machine': Creating the picture book

Studio research

Studio investigation of narrative, characterization, design elements/layout, genre

In addition to describing studio research, this section incorporates findings from the wordless picture book analyses and the research into patterned colour.

As outlined previously, it was necessary while creating the story to keep in mind four key factors. These included: engaging a child audience aged five to eight years; embedding an allegorical message in the story; creating a platform for patterned colour; and communicating equally well with colour-blind and non-colour-blind readers. These factors are considered here within the categories of visual rhetoric as defined earlier.

Narrative

The research findings into the design of the selected titles indicate that the plot concepts of such books should not be too complex. Furthermore, the findings suggest that visual narratives often benefit from the use of symbolism and metaphor and that the narrative device of a journey can assist their forward momentum. Finally, the findings intimate that the themes covered in such narratives should be engaging and of high relevance and interest to the target audience.

These diverse requirements led to a fairly long gestation period for the story. Although I wrote and researched many alternative narrative forms, my early attempts at narrative construction were unsatisfactory. Some did not accommodate metaphor well, while in others the plot was too complex or there was not an obvious place for patterned colour. These initial forms of the story included self-authored plots (Figures 47 and 48),

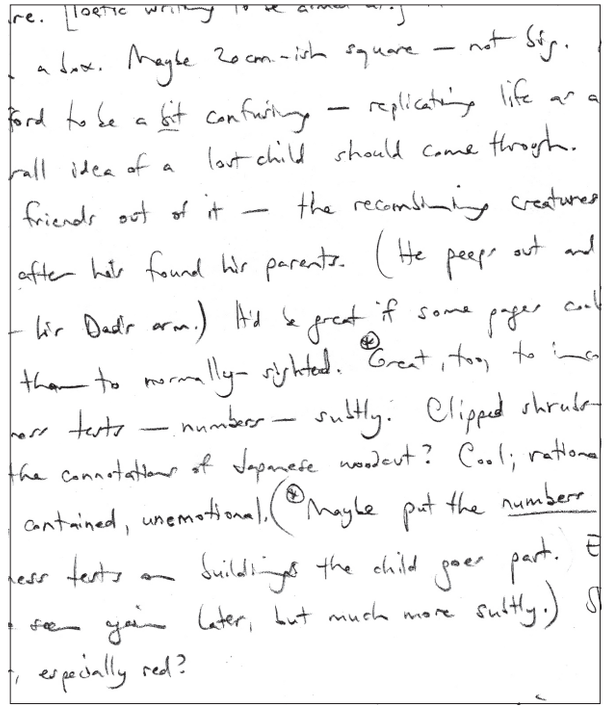

re. [Poetic writing to be aimed at.]
a box. Maybe 20cm-ish square — not 5sq.
ford to be a bit confusing — replicating life as a
rall idea of a lost child should come through.
friends out of it — the recombining creatures
after he's found his parents. (He peeps out and
- his Dad's arm.) It'd be great if some pages could
them to normally-sighted. Great, too, to in
more texts — numbers — subtly. Clipped shrubs
the connotations of Japanese woodcut? Cool; rational
contained, unemotional. (Maybe put the numbers
ese texts on buildings the child goes past.
see again later, but much more subtly.)
especially red?

Figure 47: *Workbook writing about narrative.*

a narrative inspired by a traditional Japanese folk tale, and a variation on the folk tale. Eventually I developed a wordless fantasy story that seemed to fulfil all my requirements.

The key character of *The Machine* is a toy that belongs to a colour-blind boy. In the narrative the toy is transported via the boy's dream to a strange world of odd creatures and unusual colours, where it is befriended by one of the inhabitants. Soon afterwards, a huge machine that dominates the world plunges both characters into a frightening and confusing adventure. After several incidents in which the toy is tossed helplessly here and there, it finally takes control and conquers the machine. As a result of the toy's actions, the machine is compelled to become useful.

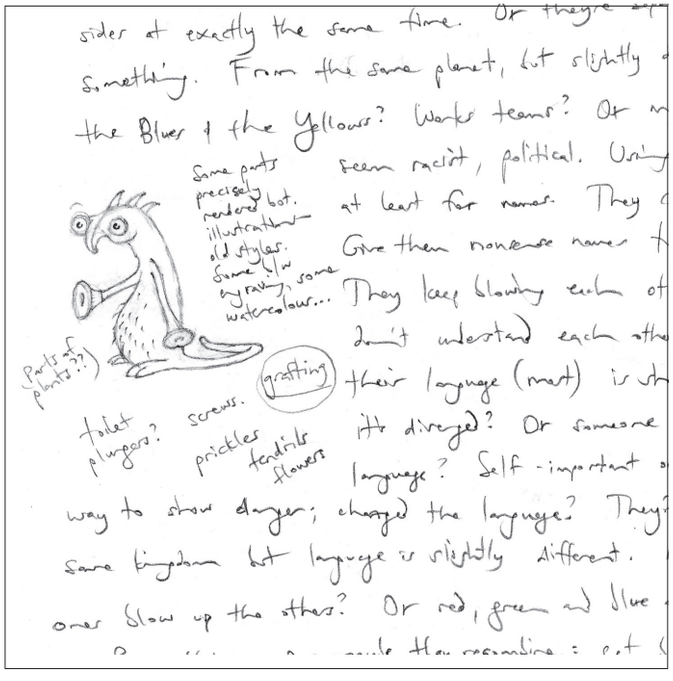


Figure 48: *Workbook writing about narrative.*

To compensate for the absence of words, the picture book employs the narrative device of metaphor. The story incorporates a metaphor for the situation of colour-blind people, who live in a world that is designed by – and for – those with full colour vision. The latter equate with the mechanised character, the machine in the story, while the toy stands in for colour-blind viewers.

The narrative is constructed on a premise central to the thesis, namely that designers with full colour vision create visual communication design that often confuses, and sometimes endangers, colour-blind viewers. Although such design is not intended to be unclear, its effect is to create visual difficulty for colour-blind people.

The story also employs figurative and colour symbolism. Early in the tale, the machine transforms itself into a maze. This change in form is to symbolize the confusion felt by colour-blind people when confronted with ambiguous colours. The machine then metamorphoses into a prickly vine, which in a similar way is designed to suggest the feelings of entanglement and anxiety evoked by such situations. This is especially relevant if safety is involved. Finally, the machine changes into a huge wave that menaces the toy. This is intended to convey the fear that can accompany experiences of confusion and loss of power.

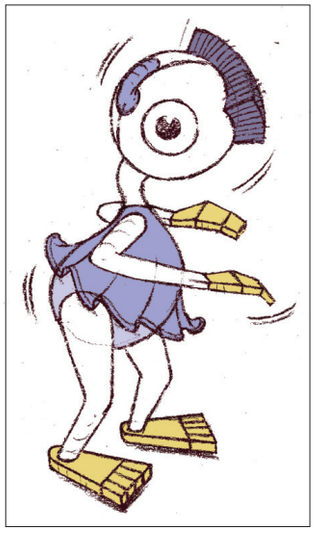


Figure 49: *Use of character conventions in* The Machine.

Characterisation

As the research findings of the ten selected titles indicate, convincing characterization can be

accomplished through the use of character conventions, expressive figurative work, and depiction of the deeds of the characters. The findings also reveal that colour symbolism and symbolic association are useful tools of characterization.

The character design of *The Machine* makes use of traditional character conventions. 'Cute' characters often have big eyes, a large head, uncoordinated limbs, an innocent expression, lack of obvious gender characteristics, and a lack of concern about their personal appearance. The toy in *The Machine* is constructed from this set of conventions (Figure 49). Its childlike facial expression is intended to suggest surprise as well as innocence, as if it is constantly amazed by what is happening to it.

While the conventional features of 'cuteness' were adopted as the basis for the toy's appearance, other attributes were added to this foundation. These were relevant to the story and helped to 'tailor' the toy to the narrative.

The first drawings of the toy (Figures 50 and 51) incorporated animal features such as hoof-like feet. Subsequent development suggested that the toy would be more effective if it looked hand-made. If it had too animal-like an appearance, it would seem to be a synthesis of a live creature and a manufactured object, which would distract from the story. As a result of this developmental process the toy gradually took on a more hand-made look.

In the final design the toy is illustrated as if constructed from natural materials. While its hands and feet are depicted as painted wood, its hair is drawn to look like bristle and its body and shirt to emulate cloth. Seams visible on its body and head strengthen the impression of fabric. The toy is floppy and weak (Figure 52) and its body distorts in response to gravity (Figures 53 and 54).

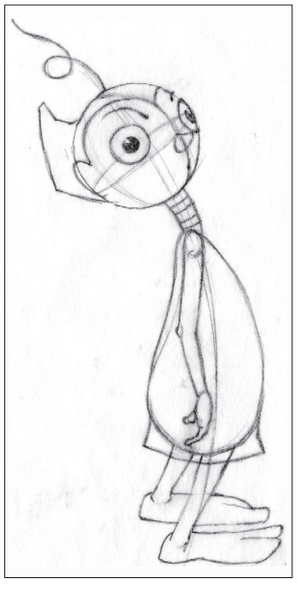


Figure 50 (lower left): *Initial drawings had some animal features.*

Figure 51 (lower right): *Early drawings lacked a fully hand-made appearance.*

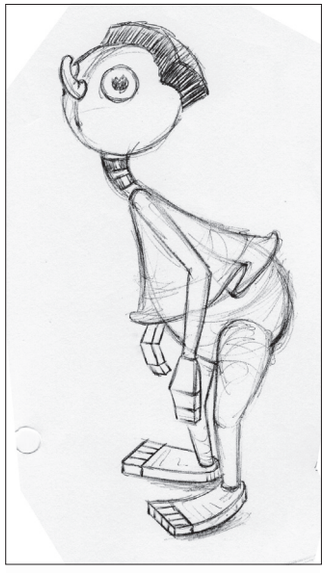


Figure 52: *The toy is drawn to look as if constructed from natural materials.*

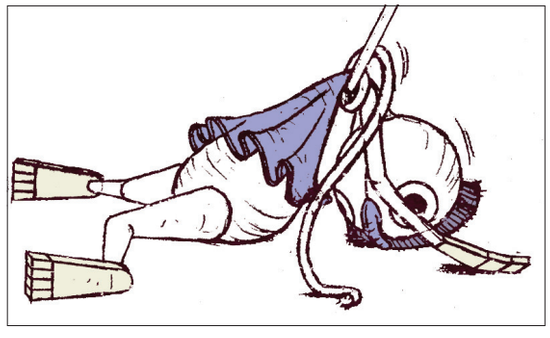


Figure 53: *The toy exhibits pliability and responds to gravity.*

The toy is characterized as being partially translucent. As a result it changes colour slightly on different backgrounds, thus implying a lack of strength or power. Moreover, its lack of a mouth and corresponding absence of a voice further implies powerlessness.

The natural materials from which the toy is made evince relative softness and pliability, warmth and pleasing textures. Furthermore, the plain construction is intended to evoke handmade qualities with all of their possible imperfections.

In contrast to this, one of the key characteristics of the machine (Figure 55) is mechanical precision. This character also draws on a set of conventions, namely those that indicate an all-powerful and dominating character. Such traits include great size, evidence of power and/or strength, and often a menacing appearance.

The machine is correspondingly rendered as if constructed from hard rigid shapes, and has mechanical features that include cogs, pulleys and wheels. These are symbolic of the machine's irresistible strength and power. Its dark, complex appearance and its size are designed to convey a powerful and potentially evil character. Its legs are firmly planted, implying an implacable attitude, while its single unblinking eye and box-like 'mouth' impart to it a sinister air.

At a more fundamental level, the machine had to look convincingly machine-like. This led to an

Figure 54: *The toy is especially floppy before it gains consciousness.*

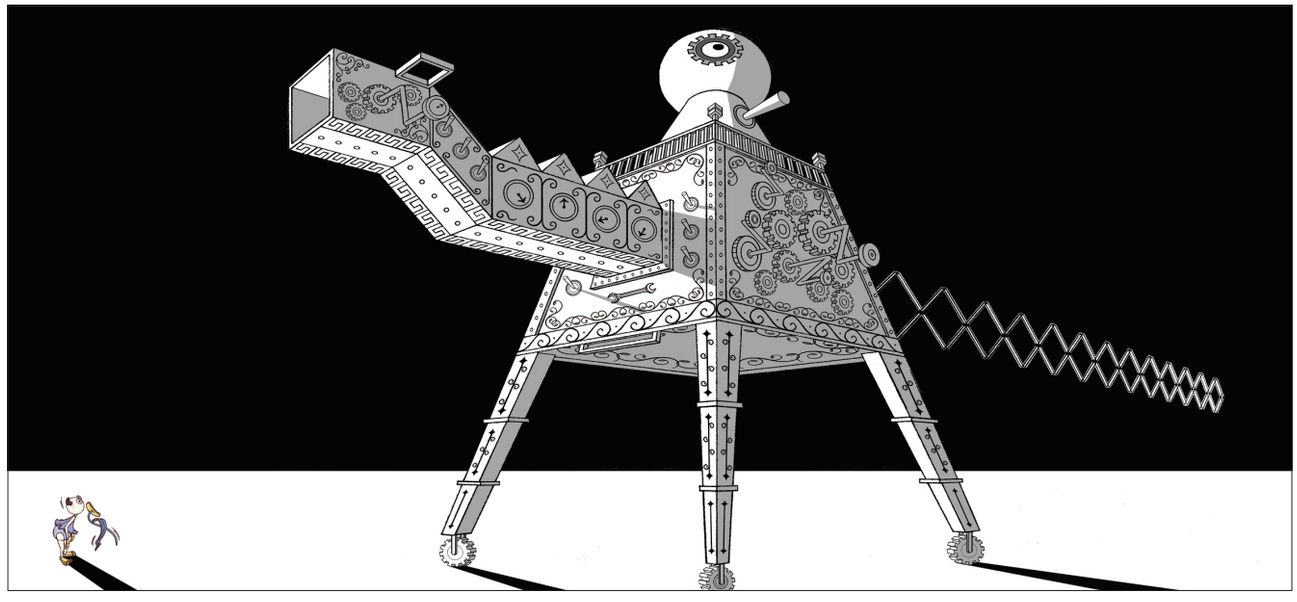


Figure 55: *The machine.*

examination of the mechanical structure of common domestic machines such as vacuum cleaners, sewing machines and lawn mowers. The aim was to pinpoint their defining visual characteristics and adapt these for the depiction of the machine (Figure 56).

The initial drawings tended to represent a quirky creation rather than a sinister one (Figures 57 and 58). As with the toy, the early developments included some animal features, such as a beak-like mouth and a moveable neck.

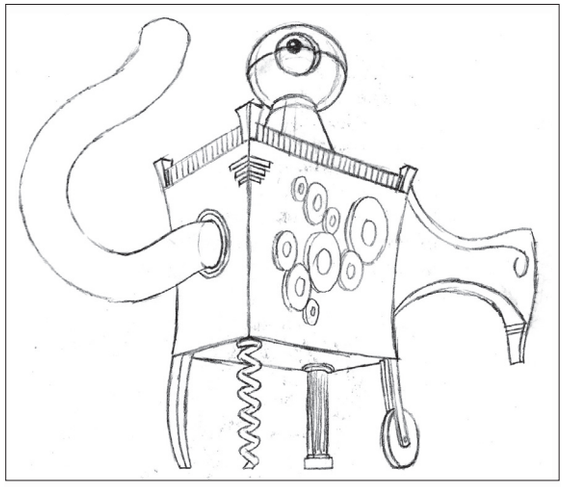
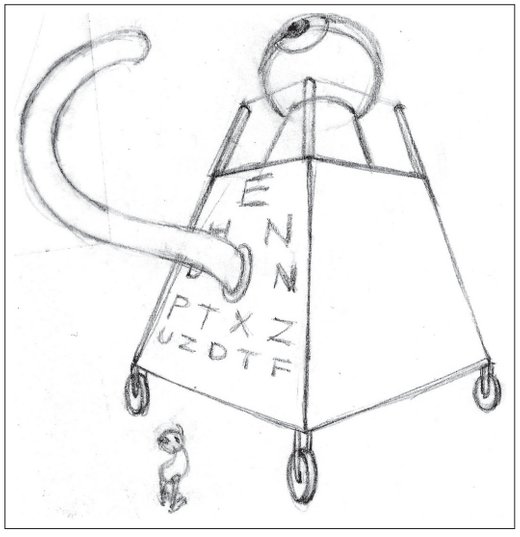
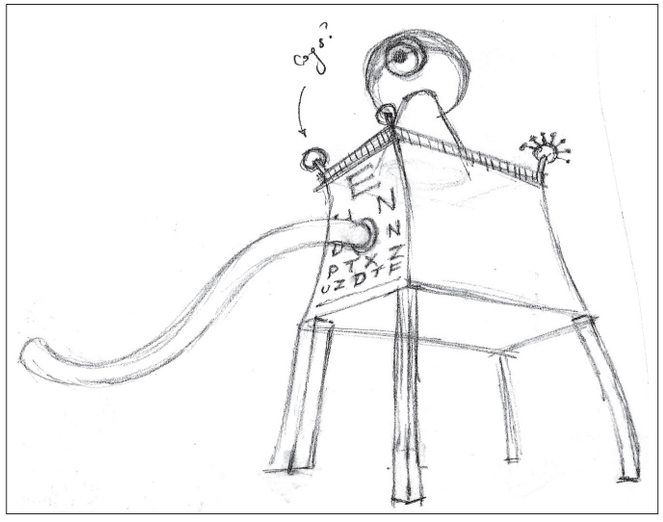


Figure 56: *Castors and a vacuum-cleaner hose were early additions to the machine.*



However, further consideration and development led to the conclusion that these design features would destroy the mechanistic impression required for the story. Machines have limited, mechanical movements, while animals can move smoothly. The one concession was in giving the final version a dragon-like neck with scales. Although this feature does not move, it is intended to add to the menacing feel of the machine.

Expressive body language and facial expression is another strategy employed in the characterization of *The Machine*. This tactic is used to communicate the idea that the toy is initially fearful and vulnerable (Figure 59). Later in the story, the same strategy is employed to indicate that the central character is also plucky and affectionate. Both behavioural characteristics are intended to make the toy endearing to readers.



Figures 57 and 58: *Early drawings for the machine.*

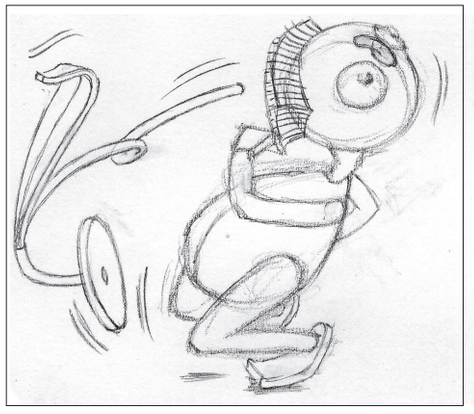


Figure 59: *The toy is initially fearful.*

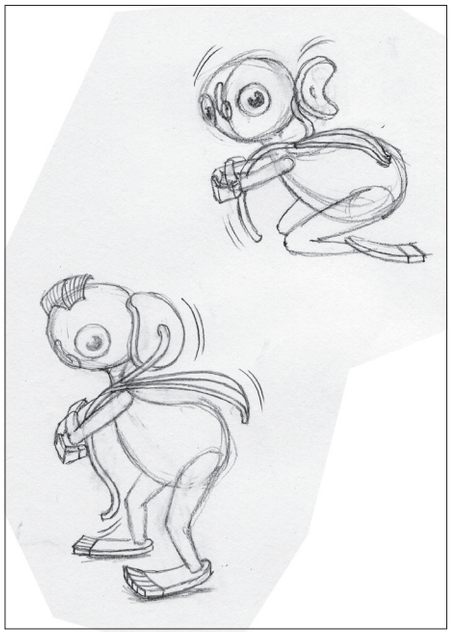


Figure 60: *The toy and flower are affectionate.*

The supporting character of the flower that befriends the toy is also affectionate, and both it and the toy display a range of expressive 'gestures' (Figure 60) that are designed to enhance their visual appeal.

The appearance and actions of these characters contrast with those of the machine. The latter is designed to be inscrutable and threatening, and to exhibit callous behaviour.

Characterization in *The Machine* employs both symbolism and association. The symbolism of making the toy translucent and voiceless has already been discussed. Similarly, the mechanical features of the machine symbolize its strength and power. Moreover, certain negative associations of machinery are intended to heighten the perceived threat of the machine. These include noise, pollution and the 'soul-less' nature of precise, mechanically-produced objects (Figure 61).

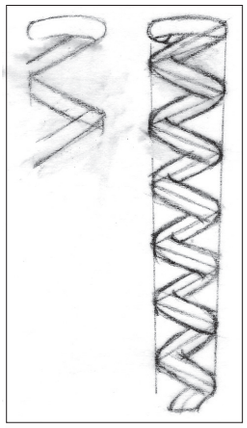


Figure 61 (top right): *The machine incorporates precise components.*

One of the most important associations used to convey the machine's character traits is that of Victorian ornament. Owen Jones believed that the Victorians used ornament with insufficient understanding, a belief that led him to produce *The Grammar of Ornament*. Victorian design is popularly associated with visual 'clutter' and confusion. As Philip Meggs (1998, p.145) puts it, 'aesthetic confusion led to a number of often contradictory design approaches and philosophies mixed together in a helter-skelter fashion'.

Figure 62 shows the title page illustration created for William Talbot's text *The Pencil of Nature* (1844). Meggs claims that this design 'demonstrates the eclectic confusion of the Victorian era. Medieval letter-forms, Baroque plant designs, and Celtic interlaces are combined into a dense symmetrical design' (*ibid.*).

In *The Machine*, Victorian ornament represents the visual confusion experienced

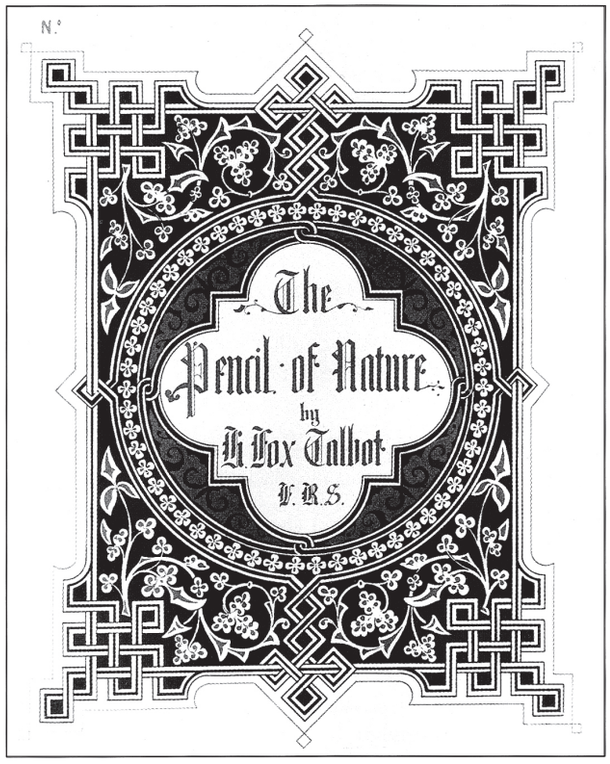


Figure 62 (bottom right): *William Talbot, title page for* The Pencil of Nature, *1844.*

by many colour-blind people when confronted with ambiguous colours. Furthermore, it symbolizes the 'unfortunate tendency' (Jones, 1856, p.1) for many designers to use colour in ways that confuse colour-blind viewers. The reason that ornament has been selected to stand in for colour in *The Machine* is that it would be impossible to illustrate the point with a cacophony of colour and still remain legible to colour-blind readers.

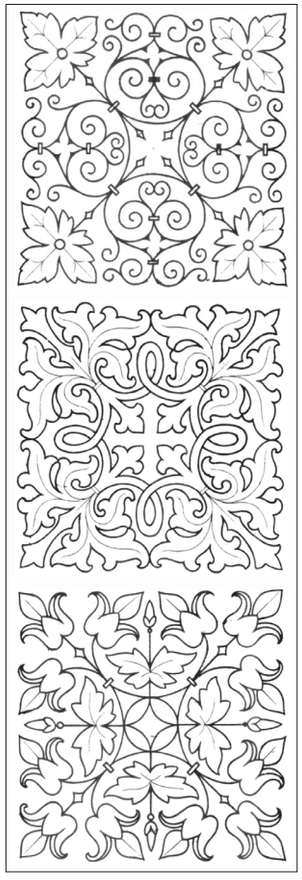


Figure 63: *Victorian ornament.*

The decision to use Victorian ornament as a visual reference led to further investigation of this stylistic form. Figure 63 shows some examples of this additional research.

Once I had chosen the Victorian motif, I found that it translated well into other areas of the book design. Victorian-inspired flourishes that incorporated references to machinery (as on the borders of these pages) were designed for the book's endpapers and title pages, and helped to unify the elements of the narrative.

A number of other visual references were considered for the surface of the machine. In the early stages of the design process, I experimented with references to ophthalmology (Figures 64 and 65). The intention was to imply that the colour-blind boy in the story had recently seen an eye doctor. The ophthalmology tools, along with the mismatched socks in the boy's bedroom, are thus designed to provide visual clues to the boy's eye condition.

However, as the character of the machine became more sinister, this approach became less desirable because of the possibility that it could cause readers to develop negative feelings about ophthalmology.

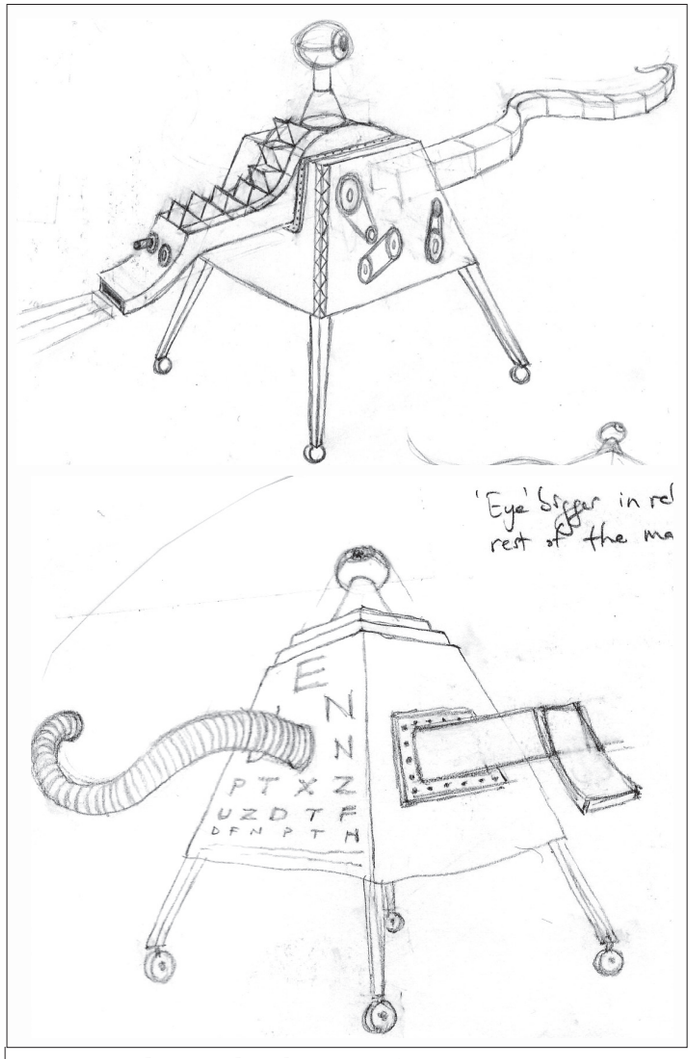


Figure 64: *Ophthalmology references were tried and rejected.*

Other visual references that were considered and rejected for the machine included road signs,

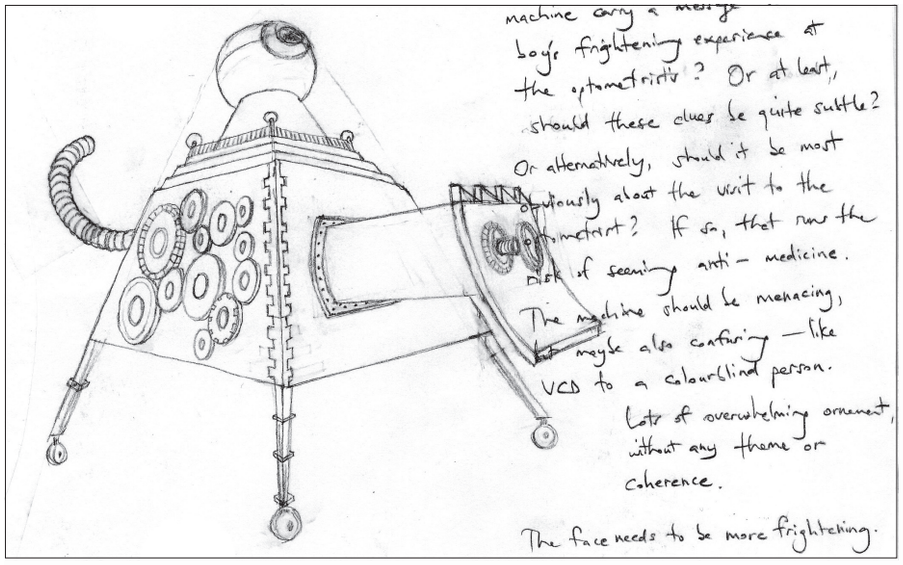


Figure 65: *More ophthalmology references.*

traffic lights and electronics. These are all visual communication design products that cause confusion for colour-blind people, but because they were not directly relevant to the story and had the potential to cause confusion, they were discarded.

Eventually the machine's surface appearance stabilised into a combination of mechanical references, including some fantastical ones, and Victorian ornament.

Design elements/layout

Wordless narratives, as the design research reveals, benefit from compositional techniques that clearly show the passage of time. In the early stages of the design process the page layouts for *The Machine* did not contain enough clues to show time passing. Further experimentation led me to adopt sequential narrative techniques, in particular comic book conventions. As a result some pages are divided into sections for clarity (Figure 66), while in others the action is aided by placement on the page and/or variation in size. In addition, close-up views (Figure 67) are used to elucidate important moments.

The design elements of colour, line, scale and space can be manipulated to enhance visual rhetoric. As one of the research aims is to make *The Machine* equally accessible to colour-blind and non-colour-blind viewers, the palette of the book is limited almost entirely to blue, yellow and black. The research findings into colour-blindness

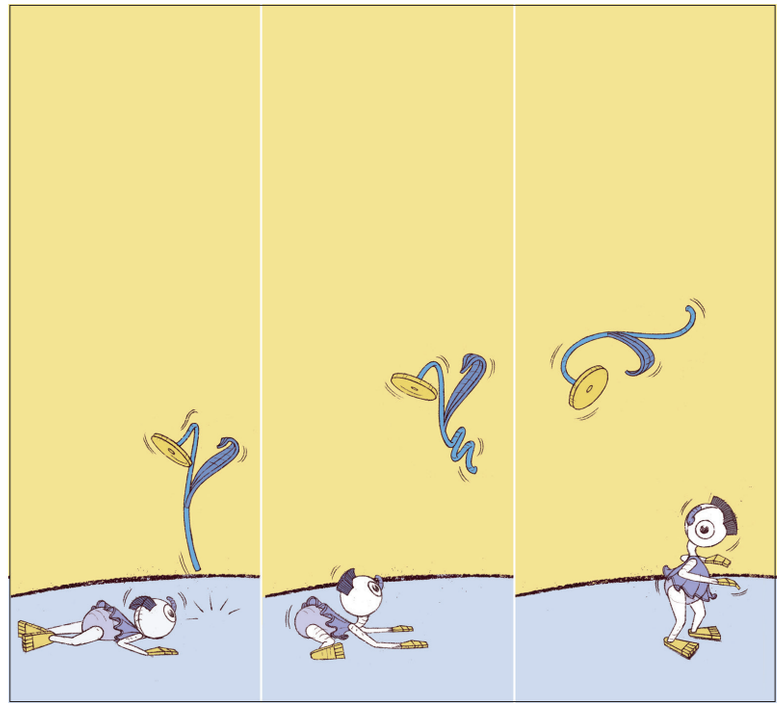


Figure 66: *Comic book conventions were adopted to show the passage of time.*

indicate that these colours are visually stable for the great majority of colour-blind people. Hence this palette is designed to appeal to colour-blind viewers, whose experience would have taught them that they have little difficulty in seeing such hues.

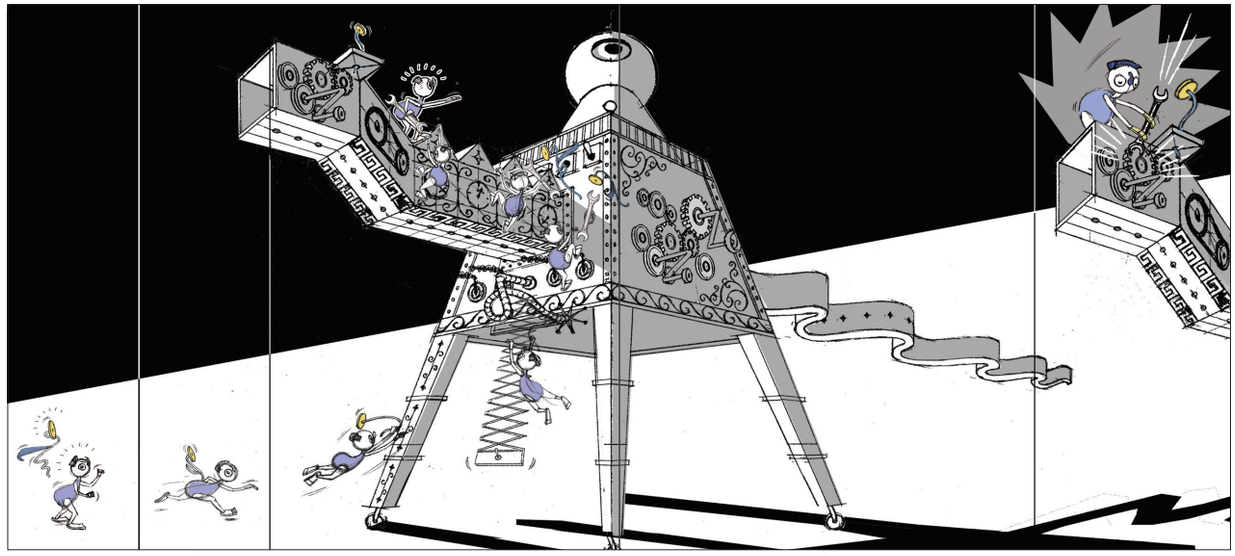


Figure 67: *Close-up views elucidate important moments, and design elements can increase the sense of drama.*

Thus, whereas the central and supporting characters of the toy and flower are depicted in blue and yellow, the machine is rendered in black and shades of grey.

The middle section of the book, in which the machine is in control, is almost entirely restricted to these tones. The selection of this stark palette and colour symbolism is intended to accentuate the sinister appearance of the machine. However, although this section is essentially achromatic, sufficient contrast ensures that it is clearly visible to colour-blind viewers.

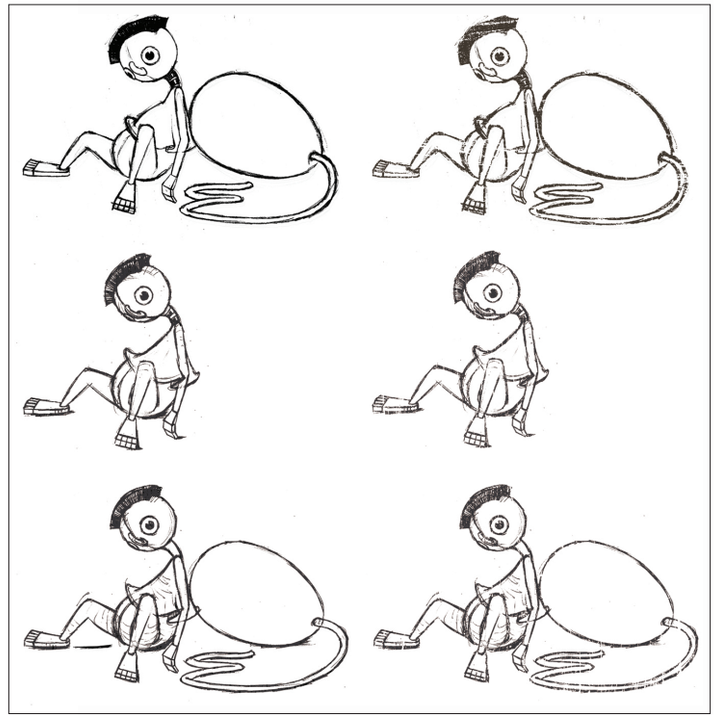


Figure 68: *Studio work with the visual effects of line. Top: EE pencil; middle: 2B pencil; bottom: biro pen. The right side in each case shows the broken-line equivalent.*

Towards the end of the book, red and green are introduced for the first time. These colours always contain pattern, thus eliminating any potential ambiguity for the reader.

Line quality can also enhance the effectiveness of visual rhetoric. The studio work investigated numerous possibilities for line work,

including biro pen, ink pen, several grades of graphite pencil, and brush work. Each example was manipulated in Photoshop to investigate how its linear and mark-making qualities could be altered.

Figure 68 shows some of the results of this early exploration. The toy is rendered with sepia-coloured broken lines that lend visual support to its soft hand-made quality. In contrast, the machine is illustrated with hard dark outlines to evoke mechanical precision.

In the central, machine-dominated section of the picture book, strong diagonals, dark lines and large areas of black are employed to increase the sense of drama.

Another design element used in the construction of the composition is scale. The arrangement of scaled objects within the page layout and their proximity to one another can suggest differences in power or importance. The most obvious example is the relative sizes of the toy and the machine. To emphasize this relationship, the machine is seen almost exclusively from below while the toy is shown primarily from above.

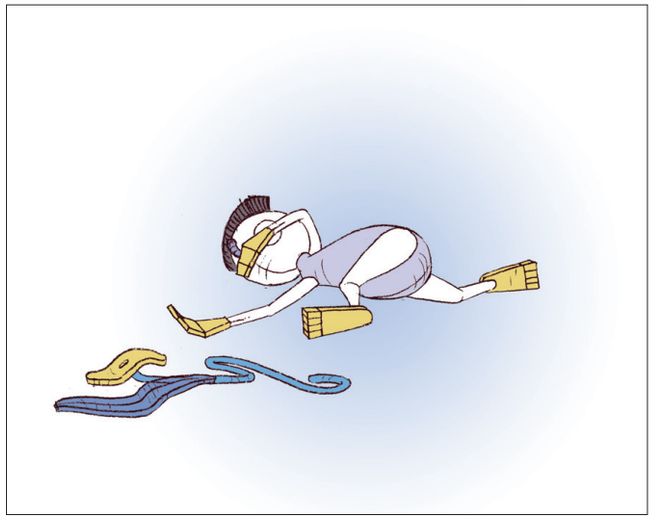


Figure 69: *Use of space to suggest isolation and vulnerability.*

Empty space can be used strategically to convey isolation, vulnerability and fear. When the toy and flower are unconscious after the machine explodes, they are depicted as small forms in the centre of a large expanse of white (Figure 69). Similarly, when the toy is threatened by a huge wave, the large areas of water and sky are intended to evoke feelings of fear and isolation.

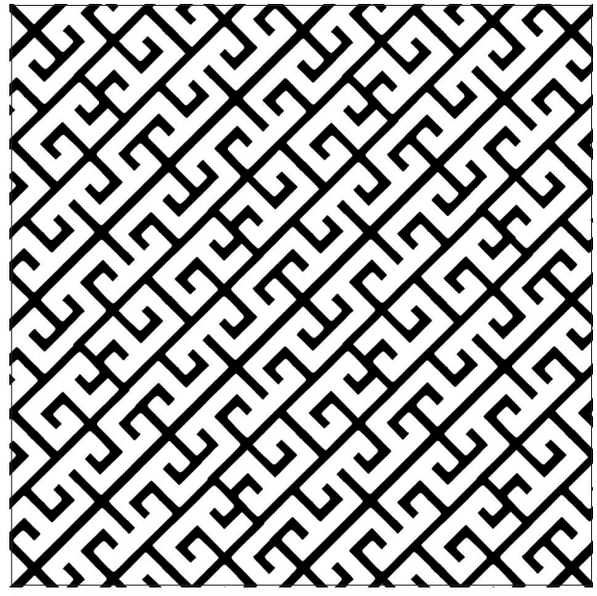


Figure 70: *The pattern for red has diagonal elements that signify prohibition and danger.*

In addition, the patterns embedded in the colours red and green are intended to contribute to the visual rhetoric. As intimated in *Development of the system*, the pattern used for each colour relates to a particular aspect of the story, thereby incorporating narrative content. An example of this is the green pattern, which makes reference to the vines that pursue the toy.

Each pattern also performs a semiotic function. The pattern for red, for example, symbolises the maze in which the toy gets lost, and incorporates diagonal elements signifying prohibition and danger (Figure 70). Similarly, the looping, tangled appearance of the green pattern is suggestive of entrapment.

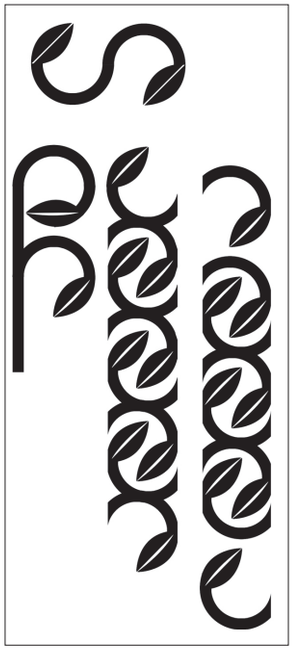


Figure 71: *Photoshop-manipulated drawings for patterns.*

The design development of the patterns was gradual. Initial studio work involved scanning hand-rendered drawings into Photoshop for manipulation (Figures 71 and 72), while another area of exploration investigated the process of screen printing and produced a number of potential solutions (Figure 73).

The flat character of the embedded patterns imparts the illustrations with a stylised, flattened appearance that is suggestive of their aesthetic precedent, *ukiyo-e*. Thus pattern, combined with the dark outlines and flat backgrounds adapted from this precedent, enhances the illustrations' overall readability.

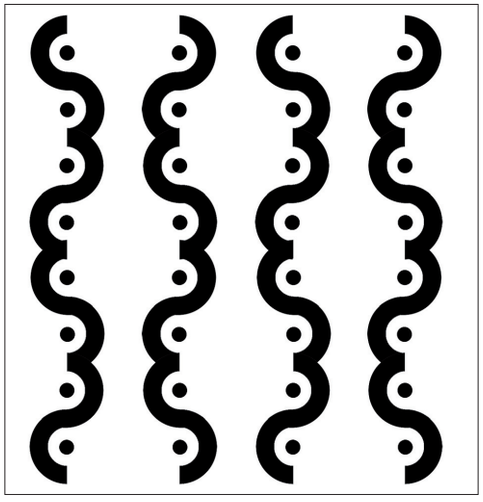


Figure 72: *Photoshop-manipulated drawings for patterns.*

Genre

The Machine is both a picture book and a fantasy tale. The genre of fantasy is particularly appropriate for meeting the reading requirements of the target audience, namely children aged five to eight. Moreover, the genre is a suitable vehicle for allegorical and educational messages aimed at older readers. These messages can then be passed on to child readers.

In addition, fantasy provides an opportunity to demonstrate patterned colour, as only in a fantasy could every-day objects magically take on a patterned appearance.

Finally, fantasy provides a space for every-day objects and landscapes to become transformed, as in *The Machine's* yellow sky and blue land. This genre thus facilitates the creation of a book that is equally

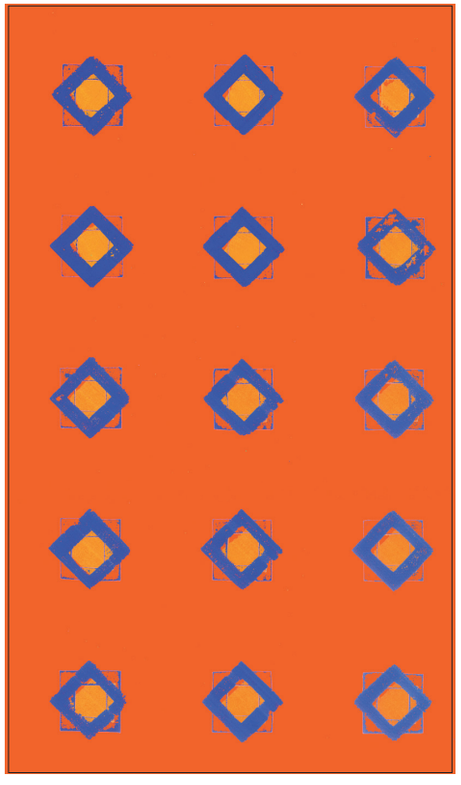


Figure 73: *Studio work with silk-screening.*

meaningful to colour-blind and non-colour-blind viewers.

The studio work focused on bringing all of these factors together. The first attempts at creating a fantasy tale (Figure 74) were unsatisfactory, but when I changed the main character from a boy to a toy, the story developed more successfully.

Like the wordless books surveyed, *The Machine* seeks to engage its target audience by using themes relevant to young children. These include large versus small, fear, power versus powerlessness, and independence. The story also includes fairy tale elements, which are considered by critics of children's literature to be engaging for young readers.

In the summary of the picture book analyses (p. 51) I discussed the educative potential of narrative. Kieran Egan, professor of Education at Simon Fraser University in Canada, states that children's

> imaginations are the most powerful and energetic learning tools. ... The story form is a cultural universal; everyone everywhere enjoys stories. The story, then, is not just some casual entertainment; it reflects a basic and powerful form in which we make sense of the world and experience. [...] children are readily and powerfully engaged by stories (Egan, 1986, p.2).

The Machine seeks to employ both the empathy-inducing and the pedagogical potential of the fantasy genre. Although *The Machine* is a wordless picture book, its visual narrative tells a story that is intended to evoke an empathetic response and to be educational. Egan claims that every 'teacher knows the engaging power of a vivid anecdote or story' (Egan, 1999, p.162).

The thesis *The Machine* (comprising both the picture book and the written portion of the thesis) incorporates three kinds of didactic content. Firstly, the picture book demonstrates how patterned colour works. Secondly, the story uses metaphor to suggest that life can be confusing and difficult for colour-blind people in our society. Finally, the written part of the thesis explains the motivation behind the creation of the story and ties together the strands of the thesis, thereby fulfilling the research aim of improving public awareness of colour-blindness.

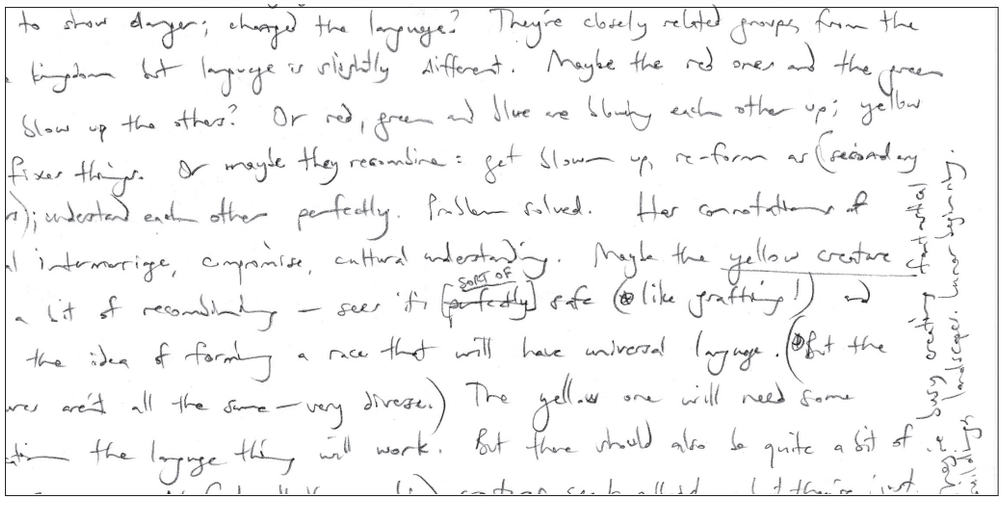


Figure 74: *Workbook notes about fantasy.*

Discussion
'The Machine': Creating the picture book

Summary

The picture book entitled *The Machine* is designed to meet four key requirements. The first of these is to engage the target audience, children aged 5-8 years. The second is to carry an allegorical message for older readers, including adults. The third is to provide a platform for patterned colour, and the fourth is to communicate equally well with colour-blind and non-colour-blind viewers. The thesis maintains that wordless picture books in the fantasy genre are well suited to this task.

To meet the above requirements, the thesis adapts strategies learnt from: analyses of existing wordless picture books; design research into techniques of visual rhetoric; and studio work addressing both precedents and research findings.

The picture book is located within the field of visual communication design, a discipline that uses both colour and pattern to ornament and to inform. It also sits within the domain of information design, a specialist area that uses colour and pattern to communicate selectively with a particular target audience. In addition, the picture book is intended to demonstrate a new system, described as patterned colour, and thus has a demonstrative role. Moreover, because *The Machine* is designed to increase public awareness about colour-blindness, it belongs to the category of visual narratives that aim to influence an audience for social good.

The book is therefore in a position to fulfil a number of aims: to be generally and selectively informative; to demonstrate the effectiveness of patterned colour; to be visually persuasive; and to be didactic.

By using a range of techniques as visual strategies and by incorporating informative and demonstrative elements usually associated with pedagogic material, the book *The Machine* extends the boundaries of the fantasy picture book genre.

Discussion
'Behind the machine': Creating the informative book

Design research

Introduction

More than any other part of this thesis, *Behind the Machine* addresses the research aim of using educational techniques to improve cultural awareness of and sensitivity to colour-blindness among those with full colour vision.

Two of the wordless picture books investigated for the thesis (*Window* and *Anno's Italy*) employ authorial postscripts. As discussed in a previous section, these explain the author's reasons for creating his or her picture book.

Although it was interesting to read these postscripts, I felt they detracted from the stories. When reading them, I felt as though the story had been merely a vehicle for a lesson, and I did not want *The Machine* to follow this example. My own story is certainly created with an educational purpose in mind. However, I also wanted it to exist independently of that role. My intention was for the picture book to be predominantly a story, without the addition of obviously pedagogic material. I thought readers might feel jaded if they reached the end of the book and were immediately faced with an instructive postscript.

After some time I realised that I would be happier with having an educational message if it were physically separated from the narrative. Each could exist in isolation from the other, and be read at different times if the reader preferred.

Furthermore, both the books could be presented in an unusual format that might interest readers from the target age group. The accordion design would create a hidden book behind whichever one the reader was engaged in.

The accordion-folded layout of *The Machine* and *Behind the Machine* was inspired by my investigation of Japanese design. Accordion folding has existed in Japan for centuries, and has been applied to art forms such as decorative folding screens and folding fans. It seemed appropriate to include it in a project that takes as its aesthetic precedents the Japanese art of *ukiyo-e* and the work of *ukiyo-e* inspired European artists. Indeed, another precedent was the work of Shinobu Ishihara, the Japanese military doctor responsible for the Ishihara Colour-blindness Plates.

Requirements of the informative book

The educational book *Behind the Machine* is conceived with three principal objectives in mind.

The first of these is to explain colour-blindness and other concepts in a way easily understood by the target group of children aged 5-8 years. This is particularly important, because if the language and imagery of the book is appropriate to that group, the information is more likely to be positively received by readers.

Secondly, the book is required to maintain the interest of readers while they learn about colour-blindness. This goal of reader engagement is intended to create optimal conditions for imparting the informative message of the book.

Finally, *The Book Behind* has the task of persuading its audience of the importance of using colour in a way that does not disadvantage colour-blind people. This objective depends on the success of the previous two.

Precedents for Behind the Machine

The design research for *Behind the Machine* included analysis of three educational children's books. These books were written for children at the lower, middle and upper boundaries of the target age range. They are, respectively, *Colors*, by Philip Yenawine (1991), *Pluck and Scrape*, by Sally Hewett (1994), and *Culture Encyclopedia: Design*, by Fiona MacDonald (2002).

The books were examined for the presence of educational techniques that could help with the design of *Behind the Machine* in the areas just outlined.

Colors, by Philip Yenawine, is one of 'a series of books on modern art created to help very young people learn the basic vocabulary used by artists, a sort of ABC of art' (Yenawine, 1991, back cover).

Each page has only a few words, from two to 36 per page, with the number increasing gradually as the book progresses. The language used is uncomplicated, stating for example that the 'world is full of colors' (*ibid.*, p.1).

The concepts explored in *Colors* are also expressed simply. One instance is the idea of advancing and receding colours, which is communicated with the words 'Can you see that the light colors seem to come toward you? And the dark ones seem to sink in?' (*ibid.*, p.17). Similarly, the book introduces pointillism with the text 'Look closely at this picture to see little dots of color. See how they blend together when you move back?' (*ibid.*, p.20).

Yenawine appears to seek to keep the attention of his readers by using ideas that are meaningful to young children. He discusses colours that are painted neatly or messily, and those that suggest dreams, and he compares paintings to puzzles and games. He also describes colours as happy or pretty, sad or serious. Finally, he challenges his readers with a suggestion likely to appeal to his young

audience, namely 'to create some colorful pictures ... to make a noisy picture? A funny one?' (*ibid.*, p.22).

Pluck and Scrape is also part of a series. According to the publishing statement on its back cover, it contains 'stimulating activity ideas on popular themes' and contains simple, 'clear instructions show[ing] how to do a wide range of projects, using readily available materials' (Hewitt, 1993).

The language used by Sally Hewitt is slightly more complex than that of *Colors*. However, as in Yenamine's book, concepts are explained in simple terms. Early in the book, the text states that sound waves 'are made when air vibrates. This means the air moves back and forth very, very, fast' (*ibid.,* p.2). The author also tends to use short sentences, and avoids contractions that might confuse young readers. On the other hand, she includes onomatopoeic words such as 'pluck' and 'twanger' (*ibid.,* p.18) that are likely to appeal to children.

The text is interspersed with explanatory diagrams that break up the blocks of text and increase the visual variety of the pages. The book also features large photographs of children carrying out the activities described. Portraying children of the reader's age making the objects in the book is a tactic for increasing engagement among the target group.

The series of books to which *Pluck and Scrape* belongs includes the heading 'Get set... Go!' on all of its front covers. Each activity in the book conforms to this theme by beginning with a section entitled 'Get ready' that lists the materials required. The following section, which sets out the steps for contruction of each project, is headed '...Get Set'. The third segment, detailing the final steps of the process, is preceded by several drawn 'puffs' suggesting rapid motion and the title 'Go!' The font size of these headings increases to underscore the implied increase in excitement.

The strategy of including a phrase commonly used by children in their play is intended to hold the interest of the target audience.

The third book investigated was *Culture Encyclopedia: Design*. It is intended for slightly older readers, as evidenced by the relatively sophisticated sentence structure and language. More challenging words such as 'exclusive' and 'licensing' are common, although many of these are explained within the text. The book also includes a glossary of terms for reference.

Fiona MacDonald uses a clear, easily understood writing style, and the sections of text are kept to a length manageable for readers of this age group.

As in *Pluck and Scrape*, MacDonald's book is liberally furnished with visual information. This includes photographs, cut-away diagrams, watercolour illustrations, and historical etchings and woodblock prints.

The page design also seems

calculated to attract and retain the interest of its desired audience. A 'high tech' theme runs throughout the design of the book and is expressed in shiny, metallic-looking panels used as page headers and borders. The pages are colourful, and illustrations range from simple vignettes, to in-text images, to large illustrations or photographs that bleed off the page. The resulting visual diversity is eye-catching and seems well suited to its intended readership.

Discussion
'Behind the machine': Creating the informative book

Studio research

Studio investigation of educational techniques

The findings from the analyses of educational books were taken into account in devising design strategies to fulfil the requirements of *Behind the Machine*. To recap, those requirements are: explaining colour-blindness and its effects in a way that is easily understood by the target audience; capturing and retaining the interest of the intended audience; and persuading that group of the importance of meeting the visual needs of colour-blind people.

Explaining colour-blindness to the target audience

In accordance with the aim of being easily understood by the target audience, *Behind the Machine* uses fairly simple language. Contractions and complex sentences are avoided, and challenging words are replaced with easily-understood equivalents.

Similarly, technical content is restricted to uncomplicated concepts, and these are presented in a straightforward way. The book does not, for example, discuss the physics of colour perception or list technical terms such as deuteranopia and tritanomaly.

Furthermore, the educational examples used in the book are chosen for their relevance to the intended audience. The reasoning behind this is to make the argument of *Behind the Machine* as compelling as possible to children of the target age.

Engaging the audience

Behind the Machine features Bink, the main character from *The Machine*, as a means of engaging child readers. These readers will already be familiar with the toy and (ideally) have some empathy with him. Hence Bink appears on one third of the pages of *Behind the Machine*.

He is, however, slightly different from his equivalent character in *The Machine*. He has a red shirt rather than a blue one, and is otherwise uncoloured.

The red shirt is employed to demonstrate the confusing appearance for many colour-blind

people of the colour red. In the first few pages, Bink is initially shown as he would look to those with full colour vision, and then as he would appear to colour-blind people.

The reasoning behind leaving Bink otherwise uncoloured in *Behind the Machine* is to make him appear unfinished. Whereas blue is almost universally recognised by humans, many colour-blind people have trouble identifying red. Bink's 'imperfect' visual appearance is symbolized by his incomplete form.

The book is required to be educational in a way that is appropriate for the target age group. My aim was that, as with the first objective, readers' engagement would be enhanced by the use of topics relevant to the target group. Thus, the explanatory examples given make reference to classroom activities, school sports and other pursuits likely to be familiar to children of this age.

Persuading the audience of the importance of the message

The first part of *Behind the Machine* gives instances of some of the day-to-day difficulties of being colour-blind. I deliberately begin with relatively minor problems that colour-blind people might face, then escalate through several examples to conclude with a life-threatening situation. I intend in this way to emphasize to the reader how important it is to meet the visual requirements of colour-blind people.

Later in the book, these same examples are employed to show the reader ways in which colour can be made less confusing to the colour-blind. Again, by using instances that are relevant to children aged 5-8 years, my goal is to make the argument immediate and real to the target group.

With the strategies described, I propose making the message of *Behind the Machine* memorable to its child readers. My hope is that this will influence their subsequent behaviour with respect to the visual needs of colour-blind people.

Conclusions

The design research for this thesis has identified a deficiency in how our society cares for a significant proportion of its population. This group, colour-blind people, is frequently placed at a disadvantage by visual communication design practices that fail to accommodate their visual needs.

Patterned colour is a system of communication that has been devised in response to the specific requirements pinpointed by the design research. As outlined in the summary on page 49, those needs include a visual means by which colour-blind people can quickly and reliably recognise colour.

The practice of employing colour to convey information is deeply embedded in numerous fields, including education, traffic safety and electronics. This practice is helpful for the majority of the population. Therefore, it seems important to seek a system whereby designers can continue to use colour for its full range of expressive and informative possibilities, without the attendant problem of handicapping the colour-blind.

Patterned colour appears to achieve its purpose of enabling colour-blind people to identify otherwise confusing colours. It also has the potential to be beneficial in a number of colour-based applications.

One such application is in the field of education, specifically in the design of illustrated books for emergent readers aged five to eight. Another education-related usage is in the colour coding of instructional books and materials.

The research findings suggest that patterned colour could also make an important contribution in the field of information design. However, more study is necessary before any definite conclusions can be drawn.

The picture book *The Machine* has been created to demonstrate patterned colour. It presents this system as a means of communicating effectively with colour-blind people and thus providing them with visual equality.

Moreover, the picture book demonstrates that children's literature can serve as a vehicle for broadening the cultural role of patterned colour as a communicative system.

The story also operates as a metaphor for the situation of colour-blind people in a world designed by those with full colour vision. However, this additional meaning is aimed primarily at older people viewing the book along with child readers.

Behind the Machine is intended to inform its target audience about the realities of being colour-blind. In addition, it demonstrates how those with full colour vision can avoid causing confusion for colour-blind people. This fulfils another need highlighted by the design research, namely to achieve greater public awareness of the visual needs of colour-blind people.

In situations where patterned colour is impractical, an alternative approach is improved education about colour-blind-safe visual practices. A list of such practices has been collated from the design and studio research for this thesis, and is given in Appendix 3.

Appendix 1:
Covering letter and participant consent form

A covering letter and participant consent form were sent to all prospective participants of the study. These read as follows.

Master of Design Thesis
Enhancing the Communicative Potential of Colour

Dear _____

I am writing to ask if you would be willing to participate in a small informal study concerning colour-blindness.

I am undertaking a Master of Design within the College of Creative Arts at Massey University. My major is illustration, which falls within the wider discipline of visual communication design, or V.C.D.. V.C.D. encompasses any design artefacts that communicate information visually, for example signage, packaging, logos, illustration, advertising and even emergency vehicle livery.

The project will investigate the use of colour in V.C.D. and how such use affects colour-blind people. Previous investigations (mine and others') have suggested that awareness of the visual needs of colour-blind people is generally inadequate among both professional and amateur designers.

My previous work has also indicated a potential role for a visual system designed to enhance the communicative properties of colour.

My work in this area is focused on two research aims. The first is improving general awareness of and sensitivity to the visual needs of colour-blind people. The second is creating a visual system whereby colour can be made equally visible to colour-blind and non-colour-blind people.

I would be very grateful if you would agree to assist with these aims. This would involve providing feedback about a number of images (twenty to thirty) that illustrate the visual system mentioned; I would send these to you through the post. The images would be accompanied by a short questionnaire in which you could record your responses to the images.

I would be keen to follow up the questionnaire, with one or two participants who were agreeable to it, with a face-to-face interview.

This would be valuable in revealing the 'personal' side of this issue. Being able to include personal anecdotes in my research would add tremendously to the likelihood of engaging the intended audience. Michael Q. Patton, the author of Qualitative Evaluation and Research Methods (1990), states that 'the intended users [of the research] ... must be interested in the stories, experiences, and perceptions of program participants.' Elsewhere he notes that evaluation case studies 'have all the elements of a good story.' These interviews, which would take place face-to-face, would be kept to a minimum of twenty to thirty minutes unless participants agreed otherwise. They would be digitally recorded to ensure accuracy of transcription.

Your responses would be used to analyse the effectiveness of the visual system under study. These responses would be treated as confidential, and would be presented anonymously in the thesis. They would not be used for any other work or publication without your consent. Each participant would be identified in the thesis by gender and age, e.g. 'M, 38'. The data gathered would be stored securely, and would not include any identifying details other than the initials of each participant's name and his or her age.

If you took part in the study, you would have the right to refuse to answer any particular question, and to withdraw from the study at any time; you could also ask any questions about the study that occurred to you during your participation. My contact details and those of my supervisors are below.

I am hopeful that this work will enhance knowledge of the visual needs of colour-blind people, and lead to greater sensitivity on the part of those who create visual communication materials.

One of the final outcomes of the research will be a children's picture book. It will be designed both to demonstrate the visual system developed during the project and to enhance public awareness of the visual needs of colour-blind people. Once it is complete, I would be happy to provide you with a CD-ROM copy should you wish to see it.

(My contact details and those of my supervisors were included here.)

Committee Approval Statement

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor Sylvia Rumball, Assistant to the Vice-Chancellor (Research Ethics), telephone 06 350 5249, email humanethics@massey.ac.nz

Enhancing the Communicative Potential of Colour

Participant Consent Form

This consent form will be held for a period of five (5) years.

I have read the covering letter and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand that I have the right to withdraw from the study at any time and to decline to answer any particular questions.

I agree to provide information to the researcher on the understanding that my name will not be used without my permission. The information will be used only for this research and publications arising from this research project.

I agree to participate in this study under the conditions set out in the covering letter.

Signature:

Name:

Date:

Appendix 2:
Responses to patterned colour test images

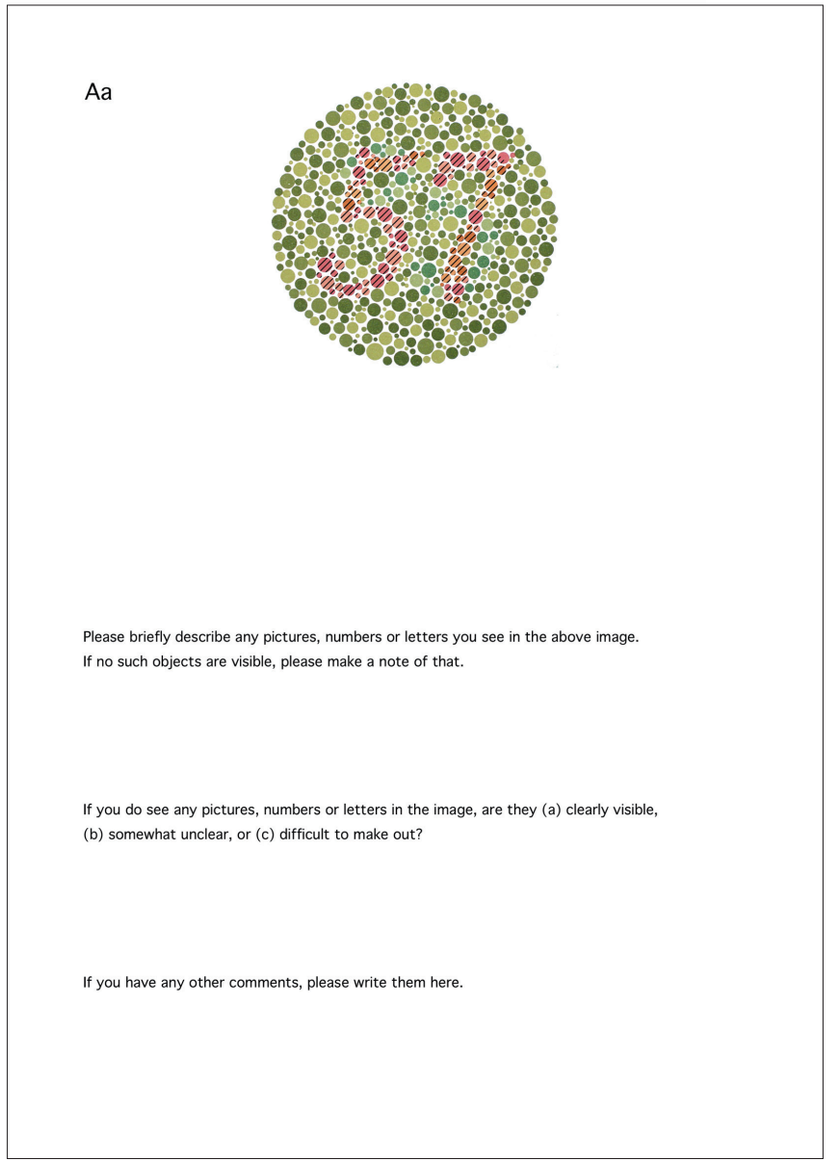


Figure 75: *Sample page from patterned-colour booklet.*

The following pages show the results of the tests into the effectiveness of patterned colour.

The test images were bound into A4 booklets and posted to the six people who had agreed to participate. They were asked to describe what they saw in each of the images, if anything, and in some instances to compare pairs of images and decide whether one of the two was more effective in conveying colour information.

The cover of the booklet carried the title of the study and the words 'The images are intended to be looked at in the order they occur in the booklet, and ideally not to be compared to one another.'

The participants replied by post, and their responses were entered into computer files. The results were analysed to discover whether embedded pattern aided identification of certain colours in the test images.

Figure 75 shows a sample page from the booklet of test images.

Patterned Colour Responses: M, 76.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Aa.jpg	57.	Clearly visible. Cross hatching helps.	Red 57 on green ground. Dark diagonal pattern, medium.	Yes.
Boy 1.jpg	Green garment, red cape, purple shoes.		No patterns.	No, could see colours anyway.
Boy 2.jpg	No change.		Simple patterns.	No, could see colours anyway.
Boy 3.jpg	Same as last.		Complex patterns.	No, could see colours anyway.
Bush scene 1.jpg	Red disc on tree.	No difficulties. Familiar experience in bush. Red difficult to see, orange better.	Red marker on tree, no white diagonal.	Yes.
Bush scene 2.jpg	Red disc with white cross hatch.	White cross hatch draws eye to the disc. Red of disc otherwise not conspicuous.	Red marker on tree, white diagonal.	Yes.
Cc.jpg	7.	Clearly visible. Cross hatching helps.	Green 7 on red ground. Dark horizontal pattern, medium.	Yes.

Patterned Colour Responses: M, 76, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Fruits 1.jpg	Red and green blobs on white field. Red blobs on green field.		Green and orange fruits, no pattern.	Yes.
Fruits 2.jpg	Left: green and red blobs more clearly differentiated. Right: red more clearly seen in cross-hatched section.		Green and orange fruits, pattern.	Yes.
Gg.jpg	3.	Somewhat unclear.	Red 8 on green ground. No pattern.	Yes.
Graph 1.jpg	Red left, green right. Black field.	No difficulties.	No pattern.	No, could see colours anyway.
Graph 2.jpg	Same as last.		Pattern, medium.	No, could see colours anyway.
Hh.jpg	2.	Clearly visible. Cross hatching helps.	Red 2 on green ground. White diagonal pattern, bold.	Yes.
Jj.jpg	57.	Clearly visible. Less clear than with dark cross hatching.	Red 57 on green ground. White diagonal pattern, medium.	Yes.

Patterned Colour Responses: M, 76, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Ll.jpg	Nothing.		Red 57 on green ground. No pattern.	Yes.
LM wheel.jpg	[Colours interpreted without difficulty.]		Colour code wheel.	N.A. (no patterned version).
Nn.jpg	No[thing].		Red 2 on green ground. No pattern.	Yes.
Pp.jpg	29.	Clearly visible. Cross hatching helps.	Red 29 on green ground. Dark diagonal pattern, medium.	Yes.
Reading rods.jpg	Colour of blocks relatively easy to see & distinguish.		Colour-coded learning tools.	N.A. (no patterned version).
Resistors.jpg	Small size and juxtaposition make recognition of some difficult.		Standard resistor colour scheme.	N.A. (no patterned version).
Ss. jpg	No[thing].		Red 29 on green ground. No pattern.	Yes.
Traffic light 1.jpg	Colours from above: red, yellow, green.	No [difficulties].	No patterns.	No, could see colours anyway.

Patterned Colour Responses: M, 76, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Traffic light 2.jpg	Same traffic lights – no clearer than earlier.		Patterns.	No, could see colours anyway.
Uu.jpg	2.	Clearly visible. Cross hatching helps.	Red 2 on green ground. Dark diagonal pattern, bold.	Yes.
Vv.jpg	No[thing].		Green 7 on red ground. No pattern.	Yes.
Xx.jpg	8.	Clearly visible. Cross hatching helps.	Red 8 on green ground. Dark diagonal pattern, medium.	Yes.

Patterned Colour Responses: M, 49(B).				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Aa.jpg	57.	Clearly, immediately visible. Stripes are cheating.	Red 57 on green ground. Dark diagonal pattern, medium.	Yes.
Boy 1.jpg	Green suit; red cape; blue boots.	No issues.	No patterns.	No, could see colours anyway.
Boy 2.jpg	Green suit; red cape; blue boots.	No issues. In this case, the stripes obscured things a bit.	Simple patterns.	No, could see colours anyway. Stripes obscured the colours.
Boy 3.jpg	Green patterned suit; red patterned cape; blue boots.	Clear. Patterns too busy. 'Vibrating' has kicked in on the green.	Complex patterns.	No, could see colours anyway. Stripes obscured the colours.
Bush scene 1.jpg	Red dot on tree. Wasn't visible in the car, but when I moved to better light it became apparent.	What does the red dot mean? I suppose the trail to the left of it is where I'm heading.	Red marker on tree, no white diagonal.	Yes.

Patterned Colour Responses: M, 49(B), continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Bush scene 2.jpg	Red dot with white diagonal stripe.	Instant[ly visible].	Red marker on tree, white diagonal.	Yes.
Cc.jpg	7.	Instant[ly visible]	Green 7 on red ground. Dark horizontal pattern, medium.	Yes.
Fruits 1.jpg	Lots of orange dots on the green background: about 30-ish? Same number of green dots on white. (Later added 'and orange' after 'green')	Difficult. Orange on green keep 'vibrating' ... made counting very difficult. The orange dots in the white were a 2nd thought... I only noticed they weren't all green when I got really close to count them.	Green and orange fruits, no pattern.	Yes.
Fruits 2.jpg	Orange & green dots on white, orange dots on green.	Very clear. Stripes helped... both on dots and green background.	Green and orange fruits, pattern.	Yes.
Gg.jpg	3.	Slow to appear, but eventually saw the 3.	Red 8 on green ground. No pattern.	Yes.

Patterned Colour Responses: M, 49(B), continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Graph 1.jpg	Red & green bar graphs.	The red on black seems a bad choice for ANY person: dark on dark just doesn't show up very well.	No pattern.	Helped with red but not with green.
Graph 2.jpg	Red & green bar graphs.	Easy. White stripes made red MUCH clearer. Black stripes hindered green... it was already dark-on-dark... so adding black stripes reduced clarity.	Pattern, medium.	Helped with red but not with green.
Hh.jpg	2.	Instant[ly visible].	Red 2 on green ground. White diagonal pattern, bold.	Yes.
Jj.jpg	57.	Instant[ly visible].	Red 57 on green ground. White diagonal pattern, medium.	Yes.
Ll.jpg	I can see smudges of pink, but haven't managed to find numbers.		Red 57 on green ground. No pattern.	Yes.

Patterned Colour Responses: M, 49(B), continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
LM wheel.jpg	[Colours interpreted without difficulty.]	No issues. Easy to interpret. Bright bold isolated colours never a problem.	Colour code wheel.	N.A. (no patterned version).
Nn.jpg	I'm going to guess a 2 based on the very clear line through the middle.	Difficult. I tried finding the top & bottom of the 2 to confirm suspicions but no success.	Red 2 on green ground. No pattern.	Yes.
Pp.jpg	29.	Instant[ly visible].	Red 29 on green ground. Dark diagonal pattern, medium.	Yes.
Reading rods.jpg	[Colours interpreted without difficulty.]	Black letters on blue, red and purple are EXTREMELY difficult to read. Black on green is hard work but visible. I sincerely hope this hasn't been used as a genuine reading 'aid'.	Colour-coded learning tools.	N.A. (no patterned version).

Patterned Colour Responses: M, 49(B), continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Resistors.jpg	Colour coded resistors. Though I didn't make anything of the patterns... the colours were visible.	More difficult than real resistors... which have brighter, purer and more solid colours. I have always struggled with real resistors too. I buy the ones with numbers on them.	Standard resistor colour scheme.	N.A. (no patterned version).
Ss.jpg	I'm guessing 29, based on pieces I can see. I haven't managed to fill the gaps.	Difficult. The parts I can see are very clear... I just can't find the rest.	Red 29 on green ground. No pattern.	Yes.
Traffic light 1.jpg	Standard traffic light.	No issues with green, yellow, red.	No patterns.	No, could see colours anyway.
Traffic light 2.jpg	Standard traffic light with stripes.	Traffic lights have a 'context' so stripes aren't additional help. However, in single light situations I can see benefit.	Patterns.	No, could see colours anyway.

Patterned Colour Responses: M, 49(B), continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Uu.jpg	2.	Instant[ly visible].	Red 2 on green ground. Dark diagonal pattern, bold.	Yes.
Vv.jpg	No pattern. Green smudge.	Nothing there.	Green 7 on red ground. No pattern.	Yes.
Xx.jpg	8.	Instant[ly visible].	Red 8 on green ground. Dark diagonal pattern, medium.	Yes.

Patterned Colour Responses: M, 52.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Aa.jpg	I can see the number 57.	Clearly visible. The stripe in the circles helps a lot.	Red 57 on green ground. Dark diagonal pattern, medium.	Yes.
Boy 1.jpg	A boy with a long cape. The cape is red, the clothes are brown and his footwear is blue.	No [difficulty interpreting the image].	No patterns.	Would have helped had participant known that horizontal lines indicated green [stated this in interview].
Boy 2.jpg	A boy in a red cape with lines running through his clothes and the cape.	No [difficulty interpreting the image].	Simple patterns.	As above.
Boy 3.jpg	Same image as before with a different pattern on the cape and the boy's clothes.	No [difficulty interpreting the image].	Complex patterns.	As above.

Patterned Colour Responses: M, 52, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Bush scene 1.jpg	Trees and ferns in a bush scene with colours dark and light brown.		Red marker on tree, no white diagonal.	No.
Bush scene 2.jpg	A bush scene of trees and ferns with dark and light shades of brown and green.		Red marker on tree, white diagonal.	No.
Cc.jpg	I can see the number 7.	Clearly visible.	Green 7 on red ground. Dark horizontal pattern, medium.	Yes.
Fruits 1.jpg	A white on one side background and green on the other with red fruits over both sides.	It is hard to see the red fruits on the green background.	Green and orange fruits, no pattern.	Yes.
Fruits 2.jpg	The fruit looking things look both green and red to me and the ones with the lines running through are easier to see.		Green and orange fruits, pattern.	Yes.
Gg.jpg	I can see no images.		Red 8 on green ground. No pattern.	Yes.

Patterned Colour Responses: M, 52, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Graph 1.jpg	Columns of red and green.	I can only tell that the columns are different due to how light or dark they are.	No pattern.	No, could see colours anyway.
Graph 2.jpg	A bar graph of red and I think it is green or brown with lines running through each bar.	The red is OK, but I have trouble telling what the other colour is.	Pattern, medium.	No, could see colours anyway.
Hh.jpg	It looks like the number 2.	Difficult to make out.	Red 2 on green ground. White diagonal pattern, bold.	Yes.
Jj.jpg	Looks like the number 57.	Difficult to make out. The lines through the circles make it easier to see.	Red 57 on green ground. White diagonal pattern, medium.	Yes.
Ll.jpg	No objects are visible to me.		Red 57 on green ground. No pattern.	Yes.

Patterned Colour Responses: M, 52, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
LM wheel.jpg	Colours I see are red, green, blue, purple, orange and pink. [Some colours left out.]		Colour code wheel.	N.A. (no patterned version).
Nn.jpg	No objects are visible.		Red 2 on green ground. No pattern.	Yes.
Pp.jpg	I can see the number 29.	Somewhat unclear. Without the lines through the circles I would not be able to see the number.	Red 29 on green ground. Dark diagonal pattern, medium.	Yes.
Reading rods.jpg	There are a whole lot of blocks in various colours range[ing] from yellow blue, green, red and orange.	I cannot make out some of the colours.	Colour-coded learning tools.	N.A. (no patterned version).

Patterned Colour Responses: M, 52, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Resistors.jpg	Each resistor has a grey background and there is a range of colours from black, red, light blue, white, green and grey.		Standard resistor colour scheme.	N.A. (no patterned version).
Ss.jpg	I can only see circles.		Red 29 on green ground. No pattern.	Yes.
Traffic light 1.jpg	Traffic light with red, orange and green.	No [difficulty interpreting colours].	No patterns.	No, could see colours anyway.
Traffic light 2.jpg	At the top a red circle with a white stripe, orange circle in the middle and a green circle at the bottom with three lines running through it.		Patterns.	No, could see colours anyway.

Patterned Colour Responses: M, 52, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Uu.jpg	I can see the number 2 but only because of the lines through the circles.		Red 2 on green ground. Dark diagonal pattern, bold.	Yes.
Vv.jpg	I can only see coloured circles.		Green 7 on red ground. No pattern.	Yes.
Xx.jpg	I can make out the number 8.	Clearly visible.	Red 8 on green ground. Dark diagonal pattern, medium.	Yes.

Patterned Colour Responses: M, 49(A).				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Aa.jpg	Number 57.	Somewhat unclear.	Red 57 on green ground. Dark diagonal pattern, medium.	Yes.
Boy 1.jpg	Boy with red cape, green long johns, and blue? shoes.		No patterns.	No, could see colours anyway.
Boy 2.jpg	Red cape with diagonal lines. Green longjohns with horizontal lines. Blue? shoes.		Simple patterns.	No, could see colours anyway.
Boy 3.jpg	As before, but patterns are very distracting.		Complex patterns.	No, could see colours anyway. Patterns obscured the colours.
Bush scene 1.jpg	A bush scene – tree trunks and tree ferns, leaf litter on ground. Nothing special stands out.	.	Red marker on tree, no white diagonal.	Yes.

Patterned Colour Responses: M, 49(A), continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Bush scene 2.jpg	Bush scene like last one except there is a bright line on a tree trunk in the centre of the image.		Red marker on tree, white diagonal.	Yes.
Cc.jpg	Question mark a number '7'.	Difficult to make out.	Green 7 on red ground. Dark horizontal pattern, medium.	Yes.
Fruits 1.jpg	Orange and green fruit easy to see against white background. Difficult to see against green background.		Green and orange fruits, no pattern.	No, could see colours already. Pattern distracting.
Fruits 2.jpg	Orange & green dots on white, orange dots on green.	Orange and green fruit against various backgrounds. White easiest to see, then green background. Stripy background very confusing.	Green and orange fruits, pattern.	No, could see colours anyway. Pattern distracting.

Patterned Colour Responses: M, 49(A), continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Gg.jpg	Either '3' or '8' tilted towards the right.	Difficult to make out.	Red 8 on green ground. No pattern.	Yes.
Graph 1.jpg	Graph with red and green bars. Red bars hard to see..	Red bars disappear into black background.	No pattern.	Helped with red but not with green.
Graph 2.jpg	Graph as before.	Diagonal lines make red easier to see.	Pattern, medium.	Helped with red but not with green.
Hh.jpg	Ampersand or number '2'. Probably the latter.	Difficult to make out. Again, can see hatching, but overall pattern unclear.	Red 2 on green ground. White diagonal pattern, bold.	Yes.
Jj.jpg	Number '57'.	Somewhat unclear to difficult to make out. Not as clear as Aa.	Red 57 on green ground. White diagonal pattern, medium.	Yes.
Ll.jpg	Nothing stands out.		Red 57 on green ground. No pattern.	Yes.

Patterned Colour Responses: M, 49(A), continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
LM wheel.jpg	Wheel with 9 coloured slices. 3 green, 2 blue and 4 red. Top right reds are very similar.		Colour code wheel.	N.A. (no patterned version). However, some colours mis-identified.
Nn.jpg	Nothing visible.		Red 2 on green ground. No pattern.	Yes.
Pp.jpg	Number 29.	Clearly visible.	Red 29 on green ground. Dark diagonal pattern, medium.	Yes.
Reading rods.jpg	Blocks containing word components. Cannot read any of the writing on red blocks. Ones labelled vowel combinations [purple] are not much better.		Colour-coded learning tools.	N.A. (no patterned version).
Resistors.jpg	Looks like resistors with coloured bands to denote value. (12, 22) the same. (18, 27) same, (47, 56) same.		Standard resistor colour scheme.	N.A. (no patterned version).

Patterned Colour Responses: M, 49(A), continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Ss.jpg	Not really – possibly a circle on right hand side.	Difficult to make out.	Red 29 on green ground. No pattern.	Yes.
Traffic light 1.jpg	Traffic light. Red on top, then light green and green.		No patterns.	Could see colours fairly well anyway, but pattern helped with red.
Traffic light 2.jpg	White bar makes top light more obvious. Dark bars on bottom light not helpful.		Patterns.	Could see colours fairly well anyway, but pattern helped with red.
Uu.jpg	Number 2.	Clearly visible.	Red 2 on green ground. Dark diagonal pattern, bold.	Yes.
Vv.jpg	You've got to be kidding! Nothing. Random dots.		Green 7 on red ground. No pattern.	Yes.
Xx.jpg	Number 8.	Clearly visible.	Red 8 on green ground. Dark diagonal pattern, medium.	Yes.

Patterned Colour Responses: M, 46.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Aa.jpg	57.	Clearly visible. Diagonals make number very clear to me.	Red 57 on green ground. Dark diagonal pattern, medium.	Yes.
Boy 1.jpg	A boy (well I hope it's a boy) with black hair, pale skin, green "jump suit?", blue shoes with blue wings and a red cape.		No patterns.	No, could see colours anyway.
Boy 2.jpg	Same boy (?) as before, green "jump suit" has black horizontals, red cape has white diagonals, shoes blue as before – pale blue.		Simple patterns.	No, could see colours anyway.

Patterned Colour Responses: M, 46, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Boy 3.jpg	(Psychodelic) same androgynous entity "jump suit" green with inlaid green branch/leaf pattern, blue shoes, red cape with white pattern.		Complex patterns.	No, could see colours anyway. Patterns obscured the colours.
Bush scene 1.jpg	Forest scene – *Nothofagus fusca* or *N. truncata* with *Cyathea ?cunninghamii* or *C. ?medullans*.	None.	Red marker on tree, no white diagonal.	Not until diagonal was pointed out.
Bush scene 2.jpg	Exactly same bush scene as before. Same physiognomic dominants: green foliage, brown & grey brown trunks, green shrubs & ferns, brown, yellow leaf litter, green sedges.	No. I never saw anything but my son pointed out a red and white marker on a tree. I now see the white but not the red.	Red marker on tree, white diagonal.	Not until diagonal was pointed out.

Patterned Colour Responses: M, 46, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Cc.jpg	7.	Somewhat unclear. I have the odd feeling this image shows a question mark.	Green 7 on red ground. Dark horizontal pattern, medium.	Yes.
Fruits 1.jpg	LHS: white background, orange & green blobs. RHS: green background, orange blobs.	None.	Green and orange fruits, no pattern.	No, could see colours anyway.
Fruits 2.jpg	LHS: white background, orange blobs & green blobs with black horizontal lines. Middle: green background with black horizontal lines & orange blobs. RHS: green background & orange blobs.	Horizontal lines could be brown or blue?	Green and orange fruits, pattern.	No, could see colours anyway.

Patterned Colour Responses: M, 46, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Gg.jpg	3.	Somewhat unclear.	Red 8 on green ground. No pattern.	Yes.
Graph 1.jpg	I see a brown background, a green bar graph. Each column is clear, these are dated 2008.	I see 2007 but no bars corresponding to that date.	No pattern.	Yes.
Graph 2.jpg	Bar graph – background brown. Green bar columns (2008) have black horizontal lines in them, orange (2007) has white diagonals.	Clear as a bell (not sure of exact colours but can see 2007 and 2008 "data").	Pattern, medium.	Yes.
Hh.jpg	2?	Somewhat unclear. I think it's a "2" but not sure.	Red 2 on green ground. White diagonal pattern, bold.	Yes.
Jj.jpg	57.	Clearly visible.	Red 57 on green ground. White diagonal pattern, medium.	Yes.
Ll.jpg	32.	Difficult to make out.	Red 57 on green ground. No pattern.	Yes.

Patterned Colour Responses: M, 46, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
LM wheel.jpg	[The respondent identified all but one colour (purple) correctly.]		Colour code wheel.	N.A. (no patterned version).
Nn.jpg	I see nothing whatsoever.	I get a headache looking at this one!	Red 2 on green ground. No pattern.	Yes.
Pp.jpg	29.	Clearly visible. Diagonals – dark ones excellent. Can see no. very well.	Red 29 on green ground. Dark diagonal pattern, medium.	Yes.
Reading rods.jpg	[The respondent identified all but two colours (purple and a blue green) correctly.]	Reminds me of primary school days using Cuisenaries for maths!	Colour-coded learning tools.	N.A. (no patterned version).
Resistors.jpg	[The respondent was accurate with most colours but mistook blue for pink once and tended to identify red as orange and orange as dark yellow.]	Very hard to read colours. Most look the same.	Standard resistor colour scheme.	N.A. (no patterned version).

Patterned Colour Responses: M, 46, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Ss.jpg	There is something there – 20 or 29 or 33, I can't say for sure.	Difficult to make out.	Red 29 on green ground. No pattern.	Yes.
Traffic light 1.jpg	Red, yellow, green from top to bottom.		No patterns.	No, could see colours anyway.
Traffic light 2.jpg	Traffic light. Top – red with white diagonal, next yellow, bottom green with 3 dark green horizontal bars.		Patterns.	No, could see colours anyway.
Uu.jpg	2.	Clearly visible. Again dark diagonals excellent to see number.	Red 2 on green ground. Dark diagonal pattern, bold.	Yes.
Vv.jpg	Aargh. I see nothing.		Green 7 on red ground. No pattern.	Yes.
Xx.jpg	8.	Clearly visible. Again dark diagonals excellent for seeing number against hideous background.	Red 8 on green ground. Dark diagonal pattern, medium.	Yes.

Patterned Colour Responses: M, 55.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Aa.jpg	57.	Clearly visible.	Red 57 on green ground. Dark diagonal pattern, medium.	Yes.
Boy 1.jpg	Child wearing cape (red), overalls (green?, blue winged boots (wings = green), black hair or cap. Hands are same color as face.	Hair or hat – not sure which.	No patterns.	No, could see colours anyway. Pattern slightly distracting.
Boy 2.jpg	Horizontal shading of clothing, and wings on boots. Diagonal shading of cape. Diagonal shading is a bit off-putting.	No [difficulties seeing the colours].	Simple patterns.	No, could see colours anyway. Pattern slightly distracting.

Patterned Colour Responses: M, 55, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Boy 3.jpg	A more organic pattern for the clothes. The cape's pattern stands out and tends to overshadow the rest of the picture.	No [difficulties seeing the colours].	Complex patterns.	No, could see colours anyway. Pattern slightly distracting.
Bush scene 1.jpg	Looks like typical New Zealand bush scene. Dots on right hand upper trunk (circled) look odd – may be red or orange.	Not particularly ambiguous or difficult, but area around lower trunks is gloomy – hard to see in shadows.	Red marker on tree, no white diagonal.	Yes.
Bush scene 2.jpg	Disc with diagonal white stripe circled.	Disc could be some other shape. Other colours could be green or red (they are different).	Red marker on tree, white diagonal.	Yes.
Cc.jpg	7, but not very well shaped.	Somewhat unclear.	Green 7 on red ground. Dark horizontal pattern, medium.	Yes.

Patterned Colour Responses: M, 55, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Fruits 1.jpg	Looks like there are several colours: white, three shades of colour (could be green?), and a dark border.	All the shapes on the right hand side appear to be the same shade. Shapes on the left hand side appear to be two different shades.	Green and orange fruits, no pattern.	No, could see differences in colour already. Pattern slightly distracting.
Fruits 2.jpg	Some shapes with the white background have horizontal lines. Similar horizontal lines on right hand side – tend to mask the shapes in that area. The shapes on the far right hand side are easier to distinguish.		Green and orange fruits, pattern.	No, could see differences in colour already. Pattern slightly distracting.
Gg.jpg	3 and very faint 8.	Somewhat unclear.	Red 8 on green ground. No pattern.	Yes.

Patterned Colour Responses: M, 55, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Graph 1.jpg	Bar graph, two years, 2007/8, relative heights are clear.	Seems clear to me.	No pattern.	No. Pattern is distracting.
Graph 2.jpg	Same sort of graph as before, but the shading makes the graphs 'busy' and harder to see at a glance than the original.	Too busy.	Pattern, medium.	No. Pattern is distracting.
Hh.jpg	2.	Somewhat unclear.	Red 2 on green ground. White diagonal pattern, bold.	Yes.
Jj.jpg	57.	Somewhat unclear.	Red 57 on green ground. White diagonal pattern, medium.	Yes.
Ll.jpg	Nothing visible.		Red 57 on green ground. No pattern.	Yes.
LM wheel.jpg	Colours given are guesses. [Three of nine colours correct.]	Only ambiguous in as much as I'm not sure what the colours are.	Colour code wheel.	N.A. (no patterned version).

Patterned Colour Responses: M, 55, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Nn.jpg	Nothing clear.		Red 2 on green ground. No pattern.	Yes.
Pp.jpg	29.	Clearly visible.	Red 29 on green ground. Dark diagonal pattern, medium.	Yes.
Reading rods.jpg	Image too small to make any comment on the letters on the blocks.	Some colours seem too close together to be easily distinguishable.	Colour-coded learning tools.	N.A. (no patterned version).
Resistors.jpg	Very hard to list the oolours. I'd be guessing other than for white. I'd have to hold a colour chart beside them to tell what the resistor values were.	I can see variations between colours on all resistors except 10 (bottom two bands) and 22 (top two bands).	Standard resistor colour scheme.	N.A. (no patterned version).
Ss. jpg	Nothing clear.		Red 29 on green ground. No pattern.	Yes.

Patterned Colour Responses: M, 55, continued.				
Plate name	*Please briefly describe any pictures, numbers or letters you see in the above image. If no such objects are visible, please make a note of that.*	*If you do see any pictures, numbers or letters, are they (a) clearly visible, (b) somewhat unclear, or (c) difficult to make out? Please also write here any other comments.*	*Image seen by those with full colour vision.*	*Pattern helped?*
Traffic light 1.jpg	I'd be guessing at the colours – only because of typical layout would I say that they are red/yellow/green – but they might be brown, or shades of green or brown.	The colours are ambiguous, but different.	No patterns.	Yes.
Traffic light 2.jpg	White diagonal stripe across red light. Orange light – no change. Three (green?) stripes horizontally across green light.	No (ambiguity].	Patterns.	Yes.
Uu.jpg	2.	Clearly visible.	Red 2 on green ground. Dark diagonal pattern, bold.	Yes.
Vv.jpg	Nothing visible.		Green 7 on red ground. No pattern.	Yes.
Xx.jpg	8.	Clearly visible.	Red 8 on green ground. Dark diagonal pattern, medium.	Yes.

Appendix 3:
'Colour-blind safe' visual communication design practices

Although there are several types, and differing severities, of colour-blindness (see *Background*), it is possible to construct a set of rules to reduce visual confusion for virtually all colour-blind people.

Certain pairs of colours look very similar to colour-blind people. The classic and most well-known is red with green. Other pairs are pink and pale blue; blue and purple; green and brown; and even red and black.

Visual confusion occurs when two colours of similar tone are placed adjacent to one another, or embedded one within the other. An example is coloured text on a slightly lighter or darker background of the same hue. Such low-contrast colour juxtapositions can be very difficult for colour-blind people to see.

Red on black, or vice versa, can be indecipherable to some colour-blind people. In general, red is not the 'bright' colour for colour-blind people that it is for those with full colour vision. 'Road-sign yellow' and lime green are much brighter colours. Where safety is involved, colour should never be used as the only 'alert' signal, but should always be augmented with another indicator.

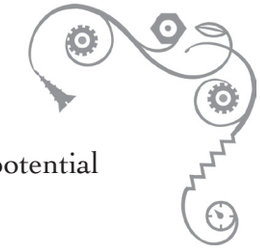
If adjacent colours are significantly different in tone, there is usually not a problem. For instance, it is generally safe to use dark red beside medium green or even medium red within dark red. However, if important information is involved, it is better to use colours that will unequivocally convey your message.

In general, a good first test of visual materials is black-and-white photocopying. If tones in an image (corresponding to colours) can still be easily differentiated after black and white photocopying, it is likely the image is suitable for colour-blind viewers.

For important information, low-saturation colours should be avoided altogether. Not only are they difficult for colour-blind people to see, they can also be confused with either white or pale grey.

'Busy' compositions with numerous colours can also cause difficulty. They are difficult to interpret, and can be distracting and even offensive.

For the great majority of colour-blind people, blue and yellow are



stable colours. Tritanomaly and tritanopy, or blue weakness and blue blindness respectively, are very rare. For such people, the colour blue is not readily recognised. Although these conditions are very rare, this is another reason to avoid ever using colour as the only indicator of important information or potential danger.

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