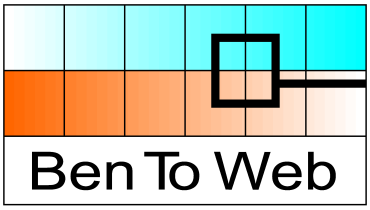
Benchmarking Tools and Methods for the Web (FP6—004275)



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D3.5 Evaluation of colour contrast module (revised)

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1 Executive Summary

It is extremely important for both accessibility and usability to provide sufficient contrast between foreground and background when rendering web content. This applies to text, diagrams and images. This deliverable concentrated on investigating appropriate equations for calculating colour contrast and appropriate minimum levels of contrast.

Four different sets of equations for calculating colour contrast were investigated:[1]

- WAI Accessibility Evaluation and Repair Tools (Ridpath and Chisholm, 2000), brightness equations (these will be referred to as the AERT/B)
- WAI Accessibility Evaluation and Repair Tools (Ridpath and Chisholm, 2000), colour contrast equations (AERT/CC)
- Thune (2003) has provided a series of equations, known at the Catman equations, using linear, quadratic and cubic functions (Catman1, Catman2, Catman3)
- WCAG2 provides a different set of equations from AERT (WCAG2)

As providing user evidence from across the entire colour spectrum could require a very large amount of user testing, it was decided to use a sample of colour combinations that are commonly used on the Web for text and background combinations. Therefore a survey of 100 popular and important websites was undertaken to provide information about common colour combinations and the 12 most popular combinations were used in the main testing.

In the user testing, 165 people with full colour vision each viewed 54 simple web pages showing a single sentence in one colour on a different coloured background. Effects of font type and size were also investigated by presenting the sentences in either Arial (a sans serif font) or Times New Roman (a serif font) and in either 10, 12 or 14 point. Participants were asked to rate how easy the sentence was to read on a 1 – 5 Lickert Scale and to comment on their rating.

Font type and size, as varied in this study, had little impact on the results, accounting for only 4% of the variance in user ratings.

[1]These equations are based upon the Luma concept and variations, as described in D5.2 and D5.3, and cannot be attributed to the authors of the references, with the exception of the power functions of Thune.

Colour contrast accounted for approximately 20 – 40% of the variance (a significant and substantial proportion), depending on the equations used. The equation which accounted for the greatest proportion of the variance in user ratings was the AERT/B equation when used in a cubic relationship to user ratings.

Using this equation, thresholds for adequate contrast between text and background were calculated, and the appropriateness of the 54 colour combinations used in the experiment calculated to provide initial examples of good and bad contrast.

2 Introduction

It is extremely important for both accessibility and usability to provide sufficient contrast between foreground and background when rendering web content. This applies to both text and image information.

In the Web Content Accessibility Guidelines Version 1.0 (Chisholm, Vanderheiden and Jacobs, 1999), Checkpoint 2.2 is "Ensure that foreground and background color combinations provide sufficient contrast when viewed by someone having color deficits or when viewed on a black and white screen".

In the draft of the Web Content Accessibility Guidelines Version 2 (Caldwell, Cooper, Reid, and Vanderheiden, 2007), Guideline 1.4.5 relates to contrast:

> "Contrast (Enhanced): Text (and images of text) have a contrast ratio of at least 7:1, except if the text is pure decoration. Larger-scale text or images of text can have a contrast ratio of 5:1 (Level AAA)"

The Research-based Web Design and Usability Guidelines from the U.S. Department of Health and Human Services (2006) also emphasise the importance of good contrast. Guideline 11.1 is "Use black text on plain, high-contrast backgrounds".

A number of different equations are available for calculating colour contrast:

- WAI Accessibility Evaluation and Repair Tools (Ridpath and Chisholm, 2000), brightness equations (these will be referred to as the AERT/B)
- WAI Accessibility Evaluation and Repair Tools (Ridpath and Chisholm, 2000), colour constrast equations (AERT/CC)
- Thune (2003) has provided a series of equations, known at the Catman equations, using linear, quadratic and cubic functions (Catman1, Catman2, Catman3)
- WCAG2 provides a different set of equations from AERT (WCAG2)

However, no evidence-based support for these ratios and equations could be found in the literature. Therefore a ecologically valid study was undertaken to investigate appropriate equations for calculating colour contrast and minimum contrast ratios.

As providing user evidence from across the entire colour spectrum could require a very large amount of user testing, it was decided to use a sample of colour combinations that are commonly used on the Web for text and background combinations. Therefore a survey of 100 popular and important websites was undertaken to provide information about common colour combinations.

3 Methodology

This section presents the methodology used to investigate the appropriate tolerances for colour contrast in relation to reading text on the World Wide Web. This study also investigated the effects of a small range of font types (serif vs. sans serif) and font sizes (10, 12 and 14 pt) on colour contrast tolerance.

3.1 Design

The majority of colour vision research is conducted in controlled laboratory environments with specific equipment, such as lighting that meets the various lighting standards from the CIE and computer displays that are calibrated to one of many standards such as ITU-R BT.601 (ITU, 2007a) or ITU-R BT.709 (ITU, 2007b). While such evaluations are important for the greater understanding of the precise effects of colour in human perception, such ideal conditions are seldom present when an individual is browsing the web in his/her home or office.

For this reason, an ecologically valid experiment that has participants evaluating colour contrast differences in their own web browsing environments (e.g., home, office, Internet café, etc.) through standard web browser interfaces was conducted in this instance. Conducting the experiment via the Web meant that a larger number of people with a broader range of characteristics could also be tested.

3.2 Participants

180 participants completed the study successfully, meaning the randomization was complete (see section 3.4.4, below).

Approximately half the participants completed the study at home and approximately half at their office, see Table 3.1 for a complete breakdown.

Table 3.1: Location where study was undertaken

Location	% of participants	Number of participants
Office	49.1	81
Home	48.5	80
University laboratory	1.8	3
Library	0.6	1
	100.0	165

The majority of participants (80%) viewed the test using a LCD monitor, with the remaining 20% using a CRT or other monitor. See Table 3.2 for a complete breakdown of monitors.

Table 3.2: Monitors used in the test

Monitor type	% of participants	Number of participants
LCD	80.6	133
CRT	17.0	28
DLP	0.6	1
TFT	0.6	1
Don't know	1.2	2
	100.0	165

3.3 Procedure

At the beginning of the study, participants were asked to complete a brief questionnaire to collect demographic and other information (see Section 7.1, Appendices).

3.3.1 Stimuli web pages

The participants were then presented with a set of web pages each with a brief text (a single sentence, a pangram with all the letters of the alphabet) with the text in Times New Roman 12pt, 14pt or 16pt in a foreground colour, specified by $C_{fg}=\left[R_{fg} \quad G_{fg} \quad B_{fg}\right]$. This text was

displayed on a background colour $C_{bg}=\left[R_{bg} \quad G_{bg} \quad B_{bg}\right]$. The background colour had a black border to set it off from the rest of the web page.

These two colours from the palette of 12 colours presented in Section 3.4.4, below, which were obtained from a survey of the popular colours currently used on a variety of popular websites (see section 7.2, Appendices).

Participants were asked to read the sentence and rate how easy it was to read on a Lickert scale from "Very easy" (=1) to "Not at all easy" (=5)

Below the Lickert scale there was a text box and participants were asked to give any reasons for why they had chosen the particular rating.

After participants had completed each stimulus page, they were shown a neutral grey web page for 5 seconds to avoid any complementary coloured after images from the stimulus.

An example stimulus web page is shown in Figure 3.1, below.

Participants were presented with a sequence of 54 stimulus pages, which they were able to complete in approximately 20 minutes.

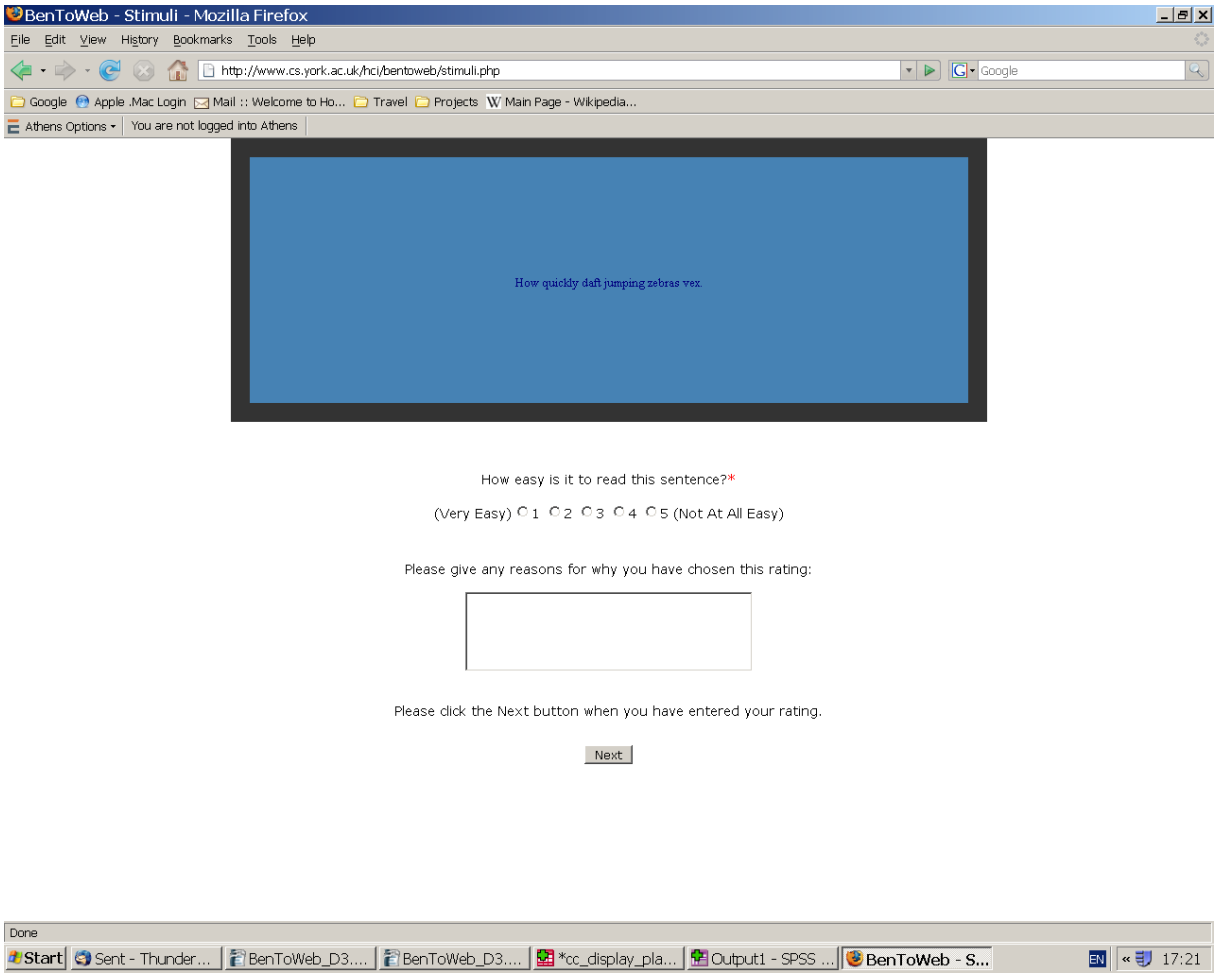

Figure 3.1: Example stimulus web page.

3.4 Colour Contrast Equations

3.4.1 WAI Accessibility Evaluation and Repair Tools

The current draft of the WAI Accessibility Evaluation and Repair Tools (AERT) guidelines (Ridpath and Chisholm, 2000) provide the following equation for calculating colour brightness:

$$Y' = ((R * 299) + (G * 587) + (B * 114))/1000$$

Given two colours, the difference between their two brightness levels is one measure of colour contrast. This equation will be referred to hereafter as AERT/B.

However, the AERT also provides the following as an alternative measure of colour contrast:

$$Contrast = max(R_{fg}, R_{bg}) - min(R_{fg}, R_{bg}) + max(G_{fg}, G_{bg}) - min(G_{fg}, G_{bg}) + max(B_{fg}, B_{bg}) - min(B_{fg}, B_{bg})$$

In this report, this equation will be distinguished by the name AERT/CC. It is unclear from the AERT documentation what ranges are ideal for proper colour contrast. The brightness calculation is claimed to have a range of 0 to 125, however, the equation evaluates to 255 when viewing black on white. For the contrast equation, the range is claimed to be from 0 to 500, but again black text on white background produces the much higher colour contrast value for 765. It is clear that user testing in this case is required to determine what ranges are ideal for web users.

3.4.2 Catman Colour Contrast Equations

A web design tool provided by Thune (2003) has been available to the web design community since 2003, known as *Catman's Color Brightness, Contrast, and Harmony Tool*. The equations used in this tool are as follows:

Colour Brightness

$$Y' = (299 * R^3 + 587 * G^3 + 114 * B^3) / (255^3 * 100)$$

This formula, when normalized such that Y' is between 0 and 1 is as follows:

$$Y' = (0.299 * (R/255)^3 + 0.587 * (G/255)^3 + 0.114 * (B/255)^3)$$

Colour Contrast

$$Contrast = \left| Y'_{fg} - Y'_{bg} \right|$$

With this equation, Thune has chosen to use the values from the ITU-R BT.601 standard for digital sampling in standard definition displays for the conversion coefficients. The selection of the exponent of 3 in what is a common brightness calculation formula is unclear. Typically, the exponent value would be the gamma value of the video display, in which case the value should be in the case of ITU-R BT.601, 2.2 (Poynton, 1996). For this reason, we will evaluate three different values as the exponent for the weighted colour coefficients in the Catman equation: 1,2 and 3. These equations will hereafter be referred to as Catman1, Catman2 and Catman3 respectively.

In the normalized version of the equation used in our evaluations generates values that vary between 0 and 1. This equation has been

empirically determined to provide the best contrast when the contrast value is between 0.6 and 1.

3.4.3 WCAG 2.0 Colour Contrast Equations

The current draft of WCAG 2.0 has another set of equations for evaluating colour contrast. They are as follows (Caldwell et al, 2007):

This formula, when normalized such that Y' is between 0 and 1 is as follows:

$$Y' = (0.2126 * (R/255)^{2.2} + 0.7152 * (G/255)^{2.2} + 0.722 * (B/255)^{2.2})$$

Colour Contrast

$$Contrast = \left| Y'_{fg} - Y'_{bg} \right|$$

As one can see, these equations are very close to the equations provided by Thune. However, in this case the conversion coefficients come from the ITU-R BT.709 standard, a standard for high definition, pixel based displays, and the exponent is the sRGB standard gamma of 2.2 (Poynton, 1996).

3.4.4 Colour combinations used in stimuli

Table 3.3, below, shows the 12 most popular text/background combinations (apart from black text/white background) from a survey of 100 popular websites (see Section 7.2, Appendices). As the most difficult yet tractable perceptual/cognitive task on the web is reading text, these colour combinations are investigated.

Table 3.3: Most popular colour combinations for text and background

	Text	Background	Frequency
1	White	Blue	33
2	Blue	Blue	29
3	Black	Grey	19
4	Grey	Grey	18
5	White	Grey	16
6	White	Green	14
7	Blue	Grey	14
8	White	Black	12
9	White	Purple	11
10	White	Red	10
11	Black	Blue	10
12	Grey	Blue	7

For combinations involving white or black (of which there are 8), 3 sub-combinations are produced, with a light, mid and dark hue of the colour and either black or white. For example, for combination 1 (white text/blue background), the following blue backgrounds can be used with white text:

Dark Blue 00 00 80

Steel Blue 46 82 B4

Light Cyan EO FF FF

There are two combinations where the text and the background are from the same colour hue (blue/blue, grey, grey). For these, all combinations of light, mid and dark hues are used, apart from the X-X combination, making 6 sub-combinations. This is illustrated for the blue/blue combination in Table 3.4, below.

Table 3.4: Sub-combinations for blue/blue

	Text	**Background**
1	Light cyan	Steel blue
2	Light cyan	Dark blue
3	Steel Blue	Light cyan
4	Steel Blue	Dark blue
5	Dark blue	Light cyan
6	Dark blue	Steel Blue

Finally, there are two combinations (Blue/Grey, Grey/Blue) where the text and the background are from different colour hues. In these cases, the full combinatorial set is used. This is illustrated for Blue/Grey in Table 3.5, below. The background grey hues are:

Dark Slate Grey 2F 4F 4F

Silver Grey C0 C0 C0

Gainsborough DC DC DC

Table 3.5: Sub-combinations for blue/grey

	Text	Background
1	Light cyan	Gainsborough
2	Light cyan	Silver Grey
3	Light cyan	Dark Slate Grey
4	Steel Blue	Gainsborough
5	Steel Blue	Silver Grey
6	Steel Blue	Dark Slate Grey
7	Dark blue	Gainsborough
8	Dark blue	Silver Grey
9	Dark blue	Dark Slate Grey

This makes a total of 54 sub-combinations.

This study also investigates the effects of font type and size on readability of text with these different colour combinations. Two font types are used, a serif (Times New Roman) font and a sans serif font (Arial/Vendana). Three font sizes will be used, 10pt, 12pt, and 14pt. Thus there are six combinations of font type and size.

The 54 sub-combinations are arranged in a random sequence (see section 7.3, Appendices) and then divided into 6 blocks of 9 trials. Each block is presented to a participant with a particular combination of font type and size. Thus groups of 6 participants are needed to ensure that each block is viewed with each font type/size combination. The order in which the blocks are presented to participants will also be rotated to avoid practice and fatigue effects. As there are 6 blocks, this means 6 orders.

Thus to ensure that all combinations are presented in all orders, groups of 36 participants are needed.

4 Results

4.1 Predicting ease of reading ratings from font size and type

A linear regression was initially conducted to investigate the effects of font size and type on the ease of reading ratings. The factors investigate were Font Type (2 levels: Arial and Times New Roman), Font Size (3 levels: 10pt, 12pt, and 14pt). Overall these two factors only accounted for 3.9% of the variance in the ease of reading ratings, a very modest result, although they were both significant predictors ($F = 133.68$, $df = 3,9716$, $p < 0.000$). The highly significant effect is partly due to the very large sample size involved – 180 participants each producing 54 ratings.

Because the effects of font size and type were so small, subsequent analyses investigating predicting ease of reading ratings just from the colour contrast equations, as this allowed for a series of non-linear regression to be conducted with far greater simplicity.

4.2 Predicting ease of reading ratings from different colour contrast equations

A series of non-linear regressions was conducted, using the different equations to predict the ease of reading ratings. In each case, linear, quadratic, and cubic equations were used in the prediction, to investigate which form of relationship accounted for the greatest proportion of the variance. Table 4.1, below, summarizes the results of these regressions. In each case, a test was also conducted to investigate whether increasing the polynomial degree of the equation significantly improves the predictive power.

Table 4.1: Summary of regressions predicting ease of reading ratings from different colour equations

Equation	F value	Significance	% of variance accounted for (Adjusted r^2)	Sig increase?
WCAG2				
Linear	2347.5	p < 0.000	19.4	
Quadratic	1903.1	p < 0.000	28.1	Yes F = 1163.7 df = 1, 9717 p < 0.000
Cubic	1713.7	p < 0.000	34.6	Yes F = 965.8 df = 1, 9716 p < 0.000
AERT/B				
Linear	4412.9	p < 0.000	31.2	
Quadratic	3026.1	p < 0.000	38.4	Yes F = 1137.4 df = 1, 9717 p < 0.000
Cubic	**2073.9**	**p < 0.000**	**39.0**	Yes F = 95.7 df = 1, 9716 **p < 0.000**
AERT/CC				
Linear	4238.9	p < 0.000	30.4	
Quadratic	2807.3	p < 0.000	36.6	Yes F = 950.9 df = 1, 9717 p < 0.000
Cubic	1942.5	p < 0.000	37.5	Yes F = 139.9 df = 1, 9716 p < 0.000
Catman1				
Linear	4412.9	p < 0.000	31.2	
Quadratic	3026.1	p < 0.000	38.4	Yes F = 1137.4

Equation	F value	Significance	% of variance accounted for (Adjusted r^2)	Sig increase?
				df = 1, 9717 p < 0.000
Cubic	**2073.9**	**p < 0.000**	**39.0**	Yes F = 95.7 df = 1, 9716 **p < 0.000**
Catman2				
Linear	4557.1	p < 0.000	31.9	
Quadratic	2830.5	p < 0.000	36.8	Yes F = 753.8 df = 1, 9717 p < 0.000
Cubic	1887.1	p < 0.000	36.8	No
Catman3				
Linear	3357.2	p < 0.000	25.7	
Quadratic	1843.4	p < 0.000	27.5	Yes F = 241.3 df = 1, 9717 p < 0.000
Cubic	1233.3	p < 0.000	27.6	Yes F = 13.4 df = 1, 9716 p < 0.005

As can be seen from Table 4.1, above, all the equations produce highly significant predictions, and account for between approximately 20 – 40% of the variance in the ease of reading ratings, a very substantial finding in a psychological experiment. The best predictor was the AERT/B (or Catman1) equations, which produced the best fitting equation – a cubic relationship between colour contrast and ease of readings ratings.

4.3 AERT/B Thresholds

In this section the thresholds for the optimal luma (brightness) difference between colours for mainstream users are determined for the AERT/B equation. The goal of these calculations is to detect the thresholds of luma

difference (or brightness to use the AERT/B terminology) that produce colour contrast ratings that are ranked highly by users.

In order to ensure a user rating of 1, where the user claims the colour combinations to be a very easy read, a cubic equation with the following coefficients must be solved:

$$ax^3+bx^2+c\,x+d=0 \quad (1)$$

After processing the data, an SPSS regression analysis provided a cubic fit equation for the user rating which included the following for the coefficients in (1), where *x* is the AERT/B value.

$$-3.62e07x^3+-0.47\,x+5.246=0 \quad (2)$$

In order to determine what the threshold is for the users to rate a pair of colours as being very easy to read, or a user rating of one, the cubic roots for this equation must be determined. The real root is as follows:

85.522 (3)

When the discriminant of the cubic equation is calculated, it is found to be:

$$4b^3d-b^2c^2+4\,ac^3-18\,abcd+27a^2d^2=2.39e(-10) \quad (4)$$

Due to the discriminant being greater than 0, there is only one real root to the equation, with the other two being a pair of complex conjugate roots. For this reason, the root (83.30,0) can be chosen as the real root and substitute 83.40 for x in the cubic equation. Indeed it is the case that 83.30 solves equation (2) to two significant digits.

Therefore it can be concluded that for users to provide a rating that text is very easy to read, or 1 on the user rating scale, the AERT/B value must be greater than 84.

If we relax the definition of what is easy to read to include user ratings of 2 or higher, we can perform the same calculation as above. Considering equation (1), with the same coefficients as (2), but instead with the user rating being a minimum of 2, the following equation must be solved:

$$-3.82e07x^3+-0.48\,x+3.219=0 \quad (5)$$

The cubic root for this equation are as follows

66.77 (6)

Once again, the discriminant is calculated for the cubic equation in (5) is determined to be positive and thus there is a single real root of 66.77, which is found to solve equation (5) with two significant digits.

Therefore, if we wish to relax our definition of what users consider easy to read, the AERT/B equation value must be higher than 67 to have users rate the text 2 or higher on the user rating scale in our test.

4.4 Catman1 Thresholds

The Catman colour contrast equation with the exponent of each weighted colour coefficient being equal to 1 produces the exact same results as the AERT/B equation. This is because Catman1 is the normalization of the AERT/B equation so that the resulting values fall between 0 and 1.

Proof 4.2.1

If the equation Catman1 is a normalization of the AERT/B equation, then the following must be the case:

$$(AERT/B)/255 = Catman1$$

and

$$AERT/B = Catman1 * 255$$

For the first half, after substituting the AERT/B equation, the following equation simplification demonstrates the equality.

$$\begin{gathered}(((R*299)+(G*587)+(B*114))/1000)/255 \\ ((R*299)+(G*587)+(B*114))/1000*255 \\ ((R*0.299)+(G*0.587)+(B*0.114))/255 \\ ((R*0.299)/255+(G*0.587)/255+(B*0.114)/255)=Catman1\end{gathered}$$

The converse has a similar simplification.

Given the above, the thresholds for the Catman1 equation can be defined as the normalization of the AERT/B values, to achieve a user rating of 1, the Catman1 value must be greater than 85 and to achieve a user rating of 2 or higher it must be greater than 67.

4.4.1 Readable threshold values

For all of the equations, the following colour combination thresholds have been established as being sufficient for highly readable text:

Table 4.2: Readable threshold values for each equation tested

Equation	Readable Threshold Value	Highly Readable Threshold Value
AERT/B (Catman1*255)	66.8	85.5
AERT/CC	437.0	947.9
Catman2	9.7	9.8
Catman3	1.0	1.1
WCAG2	26.55	27.8

4.5 Readability of the 54 colour combinations used in the study

Table 4.3: Readability of the 54 colour combinations used in the study

Text	Background	AERT/B	Highly Readable (User Rating 1)	Readable (User Rating 2)
Black	Dark slate grey	69.432	N	Y
White	Dark blue	240.408	Y	Y
Dark slate grey	Light cyan	176.299	Y	Y
Silver grey	Gainsborough	28	N	N
White	Steel blue	137.24	Y	Y
Dark blue	Light cyan	231.139	Y	Y
White	Purple	202.136	Y	Y
Black	Silver grey	192	Y	Y
White	Dark sea green	185.568	Y	Y
Silver grey	Steel blue	74.24	N	Y
White	Light Cyan	9.269	N	N
Dark slate grey	Steel blue	48.328	N	N

Text	Background	AERT/B	Highly Readable (User Rating 1)	Readable (User Rating 2)
Gainsborough	Dark slate grey	150.568	Y	Y
White	Medium orchid	125.437	Y	Y
Steel blue	Dark blue	103.168	Y	Y
White	Pale green	44.887	N	N
Dark blue	Silver grey	177.408	Y	Y
Silver grey	Dark blue	177.408	Y	Y
White	Gainsborough	35	N	N
Black	Gainsborough	220	Y	Y
Silver grey	Dark slate grey	122.568	Y	Y
Dark Blue	Steel blue	103.168	Y	Y
White	Dark red	213.439	Y	Y
Dark slate grey	Dark blue	54.84	N	N
Black	Steel blue	117.76	Y	Y
Silver grey	Light cyan	53.731	N	N
White	Black	255	Y	Y
Gainsborough	Light cyan	25.731	N	N
Dark blue	Dark slate grey	54.84	N	N
Black	Light cyan	245.731	Y	Y
White	Light salmon	70.927	N	Y
Steel blue	Light cyan	127.971	Y	Y
Light cyan	Dark slate grey	176.299	Y	Y
Dark slate grey	Gainsborough	150.568	Y	Y
Light cyan	Gainsborough	25.731	N	N
Gainsborough	Silver grey	28	N	N

Text	Background	AERT/B	Highly Readable (User Rating 1)	Readable (User Rating 2)
Steel blue	Dark slate grey	48.328	N	N
White	Medium sea green	119.105	Y	Y
White	Black	255	Y	Y
Black	Dark blue	14.592	N	N
White	Silver grey	63	N	N
Steel blue	Gainsborough	102.24	Y	Y
Light cyan	Dark blue	231.139	Y	Y
White	Red	178.755	Y	Y
Dark blue	Gainsborough	205.408	Y	Y
Light cyan	Steel blue	127.971	Y	Y
Gainsborough	Steel blue	102.24	Y	Y
White	Black	255	Y	Y
Gainsborough	Dark blue	205.408	Y	Y
Steel blue	Silver grey	74.24	N	Y
Dark slate grey	Silver grey	122.568	Y	Y
White	Thistle	53.675	N	N
Light cyan	Silver grey	53.731	N	N
White	Dark slate grey	185.568	Y	Y

5 Discussion

This study has investigated user perceptions of colour contrast of text on background on web pages, across a sample of colour combinations, text types and sizes.

Font type and size, as varied in this study, had little impact on the results, accounting for only 4% of the variance in user ratings. It is believed that this fact will hold for non-Latin alphabets, in particular for logographic languages such as Chinese and Japanese, where it has been demonstrated that the Stroop effect (which involves the reading of text in different colours) with such orthography is not greater than Latin alphabets (Lee & Chan, 2000; Yasuo, 1981; Ikeda, 1994). It is also expected to hold for non-Latin alphabets such as Hebrew (Ingraham, 1988).

Colour contrast accounted for approximately 40% of the variance (a significant and substantial proportion), depending on the equations used. The equation which accounted for the greatest proportion of the variance in user ratings was the AERT/B equation when used in a cubic relationship to user ratings.

Using this equation, thresholds for adequate contrast between text and background were calculated, and the appropriateness of the 54 colour combinations used in the experiment calculated to provide initial examples of good and bad contrast.

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7 Appendices

7.1 Introductory questionnaire

1. Where are you completing this evaluation?

a. Home

a. Office

c. Internet Cafe

d. Other, please specify:

2. What type of display are you completing the evaluation on?

a. CRT display (traditional tube display)

b. LCD (Liquid Crystal Display)

c. DLP (Digital Light Projection)

d. Plasma

e. Mobile Device – Please specify:

3. Do you have a colour vision deficiency?

a. Yes

b. No

4. If you answered Yes to Q3, what type of colour vision deficiency do you have?

a. protanomalous

b. deuteranomalous

c. tritanomalous

d. protanopic

e. deuteranopic

f. tritanopic

g. Monochromatic/achromotopsic

h. Don't know, please describe your colour vision problem:

5. Do you have dyslexia?

a. Yes

b. No

6. If you answered Yes to Q5, do you find that it is easier to read text when the text is a different colour than black and/or the background is coloured rather than white?

a. Yes

b. No

7. If you answered Yes to Q6, what colour combination do you prefer for text and background?

8. What is your native language:

a. English

b. Other, please specify:

9. If you answered Other to Q10, rate your competency in *reading* English:

(Expert) 1 – 7 (Novice)

7.2 Survey of colour combinations used on 100 popular websites

7.2.1 Introduction

As it was impossible to test the complete range of hues for colour contrast, it was decided to test a sample of the colour contrasts most commonly found on web pages. A sample of 100 popular websites was investigated for the range of colour combinations used for text and background.

7.2.2 Methodology

100 popular website homepages were investigated. These comprised:

- 15 Airlines
- 15 Universities
- 15 Banks
- 15 Online shops
- 15 Estate agents
- 25 Miscellaneous websites

For each homepage, all colour combinations of text and background, apart from black text on white background were noted.

For example, for British Airways (www.ba.com), one of the airlines, the following information was noted:

Name	URL	Colour scheme	Text / white background	Text / coloured background
British Airways	www.ba.com	Blue	Blue	Grey on blue

				Blue on yellow Blue on blue

7.2.3 Results

All combinations of text and background were collated, and Table 7.2.1 shows the 12 most commonly found combinations.

Table 7.1: Most popular colour combinations for text and background

	Text	Background	Frequency
1	White	Blue	33
2	Blue	Blue	29
3	Black	Grey	19
4	Grey	Grey	18
5	White	Grey	16
6	White	Green	14
7	Blue	Grey	14
8	White	Black	12
9	White	Purple	11
10	White	Red	10
11	Black	Blue	10
12	Grey	Blue	7

7.3 Randomization and counterbalancing of text/background colour combinations for colour contrast study

Table 7.2: Colours used – WC3 colour names and hexadecimal values

Blues:	
Dark Blue	00 00 80
Steel Blue	46 82 B4
Light Cyan	EO FF FF
Greys:	
Gainsborough	DC DC DC
Silver Grey	C0 C0 C0
Dark Slate Grey	2F 4F 4F
Greens:	
Dark Green	00 64 00
Medium Sea Green	3C B3 71
Pale Green	98 FB 98
Purples:	
Purple	80 00 80
Medium orchid	BA 55 D3
Thistle	D8 BF D8
Reds:	
Dark red	8B 00 00
Red	FF 00 00
Light salmon	FF A0 7A

Table 7.3: Randomization of text/background colours, block assignment

Trial	Block	Text	Background
1	A	Black	Dark slate grey
2	A	White	Dark blue
3	A	Dark slate grey	Light cyan
4	A	Silver grey	Gainsborough
5	A	White	Steel blue
6	A	Dark blue	Light cyan
7	A	White	Purple
8	A	Black	Silver grey
9	A	White	Dark sea green
10	B	Silver grey	Steel blue
11	B	White	Light Cyan
12	B	Dark slate grey	Steel blue
13	B	Gainsborough	Dark slate grey
14	B	White	Medium orchid
15	B	Steel blue	Dark blue
16	B	White	Pale green
17	B	Dark blue	Silver grey
18	B	Silver grey	Dark blue
19	C	White	Gains
20	C	Black	Gains
21	C	Silver grey	Dark slate grey
22	C	Dark Blue	Steel blue
23	C	White	Dark red
24	C	Dark slate grey	Dark blue
25	C	Black	Steel blue
26	C	Silver grey	Light cyan
27	C	White	Black
28	D	Gainsborough	Light cyan

29	D	Dark blue	Dark slate grey
30	D	Black	Light cyan
31	D	White	Light salmon
32	D	Steel blue	Light cyan
33	D	Light cyan	Dark slate grey
34	D	Dark slate grey	Gainsborough
35	D	Light cyan	Gain
36	D	Gainsborough	Silver grey
37	E	Steel blue	Dark slate grey
38	E	White	Medium sea green
39	E	White	Black
40	E	Black	Dark blue
41	E	White	Silver grey
42	E	Steel blue	Gainsborough
43	E	Light cyan	Dark blue
44	E	White	Red
45	E	Dark blue	Gainsborough
46	F	Light cyan	Steel blue
47	F	Gainsborough	Steel blue
48	F	White	Black
49	F	Gainsborough	Dark blue
50	F	Steel blue	Silver grey
51	F	Dark slate grey	Silver grey
52	F	White	Thistle
53	F	Light cyan	Silver grey
54	F	White	Dark slate grey

Table 7.4: Distribution of font type and size amongst first six participants

Block/ Participant	P1	P2	P3	P4	P5	P6
A	TNR/10	Arial/12	TNR/14	TNR/12	Arial/10	Arial/14
B	Arial/12	TNR/14	TNR/12	Arial/10	Arial/14	TNR/10

C	TNR/14	TNR/12	Arial/10	Arial/14	TNR/10	Arial/12
D	TNR/12	Arial/10	Arial/14	TNR/10	Arial/12	TNR/14
E	Arial/10	Arial/14	TNR/10	Arial/12	TNR/14	TNR/12
F	Arial/14	TNR/10	Arial/12	TNR/14	TNR/12	Arial/10

Table 7.5: Distribution of groups of six participants

Group of participants	**Order of blocks**
P1 - P6	A, B, C, D, E, F
P7 - P12	B, C, D, E, F, A
P13 - P18	C, D, E, F, A, B
P19 - P24	D, E, F, A, B, C
P25 - P30	E, F, A, B, C, D
P31 - P36	F, A, B, C, D, E